CHAPTER – III

THEORETICAL MODEL

3.0 Introduction

Despite several studies having appeared in the literature, the question of relationship between exchange rate and FDI still remains unresolved. The traditional view argued that FDI was not related to the foreign exchange market\(^1\). However, some studies directed attention to possible effects of real exchange rate changes on the location of domestic and international investment flows. Factors determining the effect of exchange rate on triggering relocation of production facilities across countries include barriers to entry (initial costs, i.e., the non-recoverable costs of existing industry), type of firm level exposure to risk (e.g., through price or quantity uncertainty), and degree of risk aversion of producers (Aizenman 1992). In the literature, quite often the results, both theoretical and empirical, confirm the existence of relationship between FDI and exchange rates.

Studies like Froot and Stein (1991); Klien and Rosergren (1994); Cushman (1988); Blonnigen (1997); Amuedo-Dorantes and Pozo (2001); Goldberg and Kolstad (1995); Goldberg and Klein (1997) and Kiyota, et. al. (2004) had directed attention to examining the possible effects of depreciation and appreciation of real exchange rates on the location of domestic and international investment flows. For instance, if both foreign and domestic firms were bidding for domestic asset, then depreciation of the domestic country’s exchange rate would increase the relative wealth of the foreign

\(^1\) For instance, traditional theories advocate that in the world of perfect capital markets, the source of financing of assets should not matter and hence the decision to locate abroad should not be influenced by the level of exchange rate. This is because, exchange rate changes offset differences in relative inflation by keeping the earnings in the home currency constant (Dewenter 1995). Specifically, if exchange rate is a random walk and an asset purchase price and its return are in the same currency, then the relative valuation of domestic versus foreign firm for an asset will remain unchanged.
firm and make it profitable to invest offshore. On the other hand, depreciations would lower the relative cost of production in the domestic economy, which in turn would increase FDI inflow.

Itagaki (1981), Cushman (1985), Kogut and Kulatilaka (1994), Goldberg and Kolstad (1995), and Kogut and Chang (1996) illustrated the importance of considering post-FDI changes in the exposure of a firm’s profits to exchange rate risk. If the investing firm could choose to serve foreign markets via exports or FDI, then an increase in exchange rate volatility would lead the firm to substitute FDI for exports, since FDI activity reduced the exposure of its profits to exchange rate risk (Blonigen 2005). On the other hand, if the purpose of FDI was to diversify location of production to increase the market share and to have the option of production flexibility (Aizenman 1992), then a positive relationship between uncertainty and FDI was to be expected to avoid de facto trade barriers (Sung and Lapan 2000). However, Lin, et. al. (2006) argued that an increase in exchange rate volatility tended to delay the FDI activity of a market-seeking firm, but it may accelerate the FDI activity of an export-substituting firm.

In this study, a simple theoretical model developed by Kogut and Kulatalika (1994) is adopted. The model describes the process of decision-making concerning the choice of production by considering the current exchange rate levels. Further, the study follows Goldberg and Koldstad (1995) to illustrate the nature of utility preference of risk averse investors on profit making when exchange rate uncertainty exists.

For the purpose of convenience, the theoretical framework of this study has been classified into two parts, namely (i) exchange rate levels and FDI, and (ii) exchange rate uncertainty and FDI. Further, a brief account of other factors determining FDI
along with exchange rate levels and its volatility is also given. A brief description of the econometric and time-series techniques that are to be used in this study is also given.

3.1 Exchange Rate Levels and FDI

In a model by Kogut and Kulatalika (1994), the foreign firm has a choice among three operating modes: export, local manufacturing, or no activity in the foreign market. The choice of mode is determined by expectations on real exchange rate dynamics, production function of the individual firm, and its current operating state. Once an investment is made in the foreign country, it provides the option to expand in future. This is because the investors establish brand labels and distribution channels through previous export. Thus, they intend to preserve the value of their assets by shifting manufacturer investments to the foreign country when changes in exchange rate deteriorate the terms of trade.

Kogut and Kulatalika (1994) assume that foreign investor has the choice between producing domestically and exporting to the foreign market or producing abroad, in which case direct foreign investment decisions are based on the relative profitability of various production locations. Another important assumption that follows from Sung and Lapan (2000) is that each plant is assumed to exhibit decreasing average cost, so that in a deterministic setting only one plant will be built. In addition, every plant faces a perfectly elastic demand, that is, multinational enterprises (MNEs) can sell any volume produced at the world market price. Moreover, regardless of where the firm builds its plant, it will face costs associated with the operation of the plant. However, the firm faces uncertainty about the costs of producing in the foreign country.
An important assumption of Kogut and Kulata lika (1994) is that the costs of plant built in the foreign country are expressed in foreign currency and do not depend on exchange rate (that is, only local resources are used in the production process). Similarly, the costs of plant built in the home country of the MNEs are expressed in currency of the home country. The model focuses on a single commodity market in a foreign country and assumes that this particular commodity is not produced in the foreign country, but demand is satisfied by imports. Now suppose the MNEs wants to produce this commodity in the foreign country; then the unit price of this commodity, is determined in the world market and is expressed in currency of the home country of the MNEs.

Profits received by the foreign investor have different effects due to the sign and magnitude of a change in exchange rate, which depends on location of plants and sales in home and foreign firms. The effect of foreign country devaluation on the relative profitability of producing through a foreign subsidiary is then unambiguously negative. The effect of depreciation of the foreign country currency leads to reduction in the cost of production in the foreign country. Thus, it enables to get the difference in profits.

In sum, given the cost functions and the sequence of decision making, then if devaluation of exchange rate in the foreign country increases, it lowers the cost of investment to the foreign investors and results in gain in relative profitability, and thus increases FDI. In this background, the present study could derive a testable hypothesis namely, Exchange rate depreciation increases inflow of FDI.
3.1.1 Model specification

On the basis of the theoretical framework and hypothesis formulated above, a reduced form equation relating to the effects of exchange rate levels on FDI may be specified as follows:

\[ \Delta FDI_t = \alpha + \sum_{k=1}^{p} \lambda_k \Delta RER_{t-k} + \sum_{j=1}^{n} \gamma_j \Delta FDI_{t-j} + \epsilon_t \]

\[ i = 1, \ldots, p; j = 1, \ldots, n \] ... (3.1)

where, \( t \) is a time subscript; \( \Delta \) denotes first-difference operator; \( FDI \) is Foreign Direct Investment inflows; \( RER \) denotes trade based-real effective exchange rate; \( \alpha \) is the constant term; \( \lambda_k \) and \( \gamma_j \) are the regression coefficients; \( p \) and \( n \) are lags; and \( \epsilon_t \) is the random error term. The study anticipates that if \( RER \) is negative and significant then exchange rate depreciation would favour production in foreign country by encouraging FDI. That is, firms would find it cheaper to build foreign-based production via FDI rather than to export domestic production.

3.2 Exchange Rate Uncertainty and FDI

In addition to exchange rate levels, volatility of exchange rate is also seen to matter investment decisions. This is especially an important dimension of the costs and benefits of any evaluation of different exchange rate regimes, since many capital investments are costly to reverse. The irreversible nature of investment and uncertainty about the future benefits and costs of investment may cause a wait and see attitude in making investment decisions. Foreign Investors care about uncertainty because they take into consideration the long term horizon before undertaking any investments. Therefore, FDI behavior will be responsive to the degree of investment uncertainty about future prices, rates of return, and economic conditions (Dixit and
Thus, foreign investor’s decision concerning FDI is made in an unstable macroeconomic environment.

The present study adopts the framework of Goldberg and Kolstad (1995) to examine the issue of exchange rate uncertainty on FDI flows. A brief description of their model may be in order. They examined the impact of short-term real exchange rate variability on production location. In their two-period model, a multinational produced only for foreign country and decided whether to satisfy foreign demand by exporting with domestic production or by investing in production abroad. The multinational firm maximised expected utility of profits, which depended on expected profits and the variance of profits. The authors demonstrated that with risk aversion, even when production costs were equalized between the home and foreign market, uncertainty of future exchange rate volatility affected the decision of where to locate facilities and investment flows.

Foreign investors make their investing decisions in an uncertain environment due to unstable macroeconomic environment and uncertainty about the cost of production. The Goldberg and Kolstad model shows how the expected utility from profit depends on the variability of the exchange rate and cost of production. In this case, the foreign investor forecasts the foreign investor’s behaviour at time t, using all information available up to that time.

A casual examination of their optimization problem revealed that the firm's desire to increase expected profits via holding plant in foreign country is tempered by increased exposure to currency risk. Holding foreign country’s market size constant, the affiliate will reduce the FDI as exchange rate volatility increases. In the limiting case, volatility will be high enough such that the affiliate cuts all exports and only operates in the foreign market.
To summaries, for a risk-averse foreign investor who could open a plant at home or in the host country, given the cost functions and the sequence of decision making, if the volatility of exchange rate in the foreign country increases, expected utility from investing in the foreign country decreases.

In the light of this background, the present study could derive a testable hypothesis, i.e., exchange rate volatility discourages inflow of FDI

3.2.1 Model specification

On the basis of the theoretical framework and hypothesis designed regarding the effects of exchange rate volatility on FDI, the reduced form equation may be specified as follows:

\[ \Delta FDI_i = \alpha + \sum_{i=1}^{m} \delta_i \Delta VOL_{t-i} + \sum_{j=1}^{m} \gamma_j \Delta FDI_{t-j} + \eta_i, \]

\[ i = 1 \ldots n; \quad j = 1 \ldots m \quad \text{..... (3.2)} \]

where, \( t \) is a time subscript; \( \Delta \) denotes first-difference operator; \( FDI \) is Foreign Direct Investment, \( VOL \) is volatility of exchange rate series, \( \alpha \) is the constant term, \( \delta \) and \( \gamma \) are the regression coefficients; \( n \) and \( m \) are lags; and \( \eta \) is random error term.

Equation (3.2) would identify a channel though which exchange rate volatility may affect inflows of FDI. If \( VOL \) is negative and significant then an increase in exchange rate volatility reduces inflows of FDI.

3.2.2 Measures of exchange rate volatility

Exchange rate uncertainty (volatility) is directly unobservable; hence it needs to be generated. Literature on exchange rate volatility has made use of different methods to measure volatility (see Appendix - I). In general, the future behavior of an
economic variable is uncertain since the probability of future events cannot be determined, *a priori*. Thus, future volatility of an economic variable is seen as a stochastic process that evolves over time with a random and a deterministic component (see Crawford and Kasumovich 1996, and Carruth, et. al. 2000). Though there are four alternative ways to generate exchange rate volatility, namely historical volatility, implied volatility, conditional volatility, and stochastic volatility. The present study is based on the measures of conditional volatility, and few other methods to measure volatility for exchange rate series.

The study considered Autoregressive Conditional Heteroskedasticity (ARCH) model as the Bench mark model and examined the presence of ARCH effect in exchange rate series. Once the series are identified with ARCH effect through ARCH-Langrange Multiplier (ARCH-LM)\(^2\) test, then the study proceed to compute the volatility through ARCH model. If there is no presence of ARCH effect in the series, then the study would compute volatility through moving average standard deviation (MASD) and Hodrick and Prescott (HP) (1997) method. Second, between MASD and HP model, the optimal measure of exchange rate volatility is selected through comparative model based on Akaike information criterian (AIC).

To formally compare the performance of the MASD and HP exchange rate volatility measures, each equation is re-estimated using different proxies, (MASD, HP), and then the optimal one selected on the basis of the following model selection criteria:

\[ \varepsilon_i^2 = \beta_0 + \sum_{j=1}^{p} \beta_j \varepsilon_{i-j}^2 + \nu_i \]

The ARCH-LM test statistic is computed from an auxiliary test regression. To test the null hypothesis that there is no ARCH effect upto order \(p\) in the residuals, the following regression is run:

\[ \beta_1 = \beta_2 = \beta_3 = \ldots = \beta_p = 0 \]

Thus, the F-statistic is an omitted variable test for the joint significance of all lagged squared residuals. However, the exact finite sample distribution of the F-statistic under \(H_0\) is not known but the LM test statistic is asymptotically distributed as \(\chi^2_{(p)}\) under quite general conditions.

\(^2\) The ARCH-LM test statistic is computed from an auxiliary test regression. To test the null hypothesis that there is no ARCH effect upto order \(p\) in the residuals, the following regression is run:
AIC (Model1:Model2) = LL1 – LL2 – (k1 – k2)  

where, AIC is the Akaike Information Criterion; LL1 and LL2 are the values of their maximized log-likelihood function respectively; and k is the number of regressors. If AIC>0 then M1 is preferred to M2, otherwise M2 is chosen as the optimal model. For each estimated equation, the non-nested testing sequence followed a two-stage process. First, the regression is run for exchange rate series with MASD volatility measure (M1) against exchange rate series with HP volatility measure (M2). The second stage is to obtain an optimal measure of exchange rate volatility between MASD and HP. Brief descriptions of three measures of volatility are as follows:

a) **Autoregressive Conditional Heteroskedasticity model**

    The most frequently used measure of uncertainty based on conditional volatility developed by autoregressive conditional heteroskedasticity (ARCH) model of Engle (1982), later on generalized as GARCH (Generalized ARCH) by Bollerslev (1986). When studying uncertainty, the conditional should be a better measure because it captures the unexpected volatility (Crawford and Kasumovich 1996). This model is to generate expected volatility in a series conditional on past behavior. ARCH (m) model can be written as:-

    \[
    y_t = X_t \beta + \varepsilon_t \quad \text{(conditional mean)} \quad \text{(3.4)}
    \]

    \[
    \sigma_t^2 = \omega_0 + \omega_1 \varepsilon_{t-1}^2 + \omega_2 \sigma_{t-1}^2 + \ldots + \omega_m \sigma_{t-m}^2 \quad \text{(conditional variance)} \quad \text{(3.5)}
    \]

where, \( \varepsilon_t \sim N(0, \sigma_t^2) \); \( \varepsilon_t^2 \) is the squared residuals; \( \sigma_t \) is the conditional variance of the error term; and \( X_t \) is the conditional mean of the series. Often, AR processes are used as conditional mean. In this paper, the series are fitted to \( AR(p) \) for the sample countries, where \( p \) is the lag length of the conditional mean, selected based on Akaike
Information Criterion (AIC). This model can be estimated using maximum likelihood technique to obtain an estimate of the conditional variance $\hat{\sigma}_t^2$.

b) Moving Average Standard Deviation method

The second measure, perhaps the most frequently used (Chowdhury (1993), Kenen and Rodrik (1986), Fountas and Aristotelous (2000)) is the MASD of exchange rate. This specification of exchange rate uncertainty, an unconditional measure, is commonly used in the literature like Goldberg and Kolstad (1995) and Cushman (1985 and 1988). To account for movements in exchange rate uncertainty over time, the study used time-varying measure of volatility constructed by the moving average standard deviation (MASD) of the changes in the nominal exchange rate:

$$V_t = \left[ \frac{1}{m} \sum_{i=1}^{m} (e_{t+i-1} - e_{t+i-2})^2 \right]^{1/2} \quad \ldots \ldots \quad (3.6)$$

where, $e$ is the log of exchange rate and $m$ is the order of moving average. To avoid an arbitrary choice of the order of moving average, the optimal lag structure was derived by estimating alternative dynamic specifications with $m$ set equal to 2, 4, 6 and 8, and then selecting, for each equation, the order of moving average which yielded the highest value of the Akaike Information Criterion (AIC) from the bounds test equation (Vita and Andrew 2004).

c) Hodrick and Prescott method

Hodrick and Prescott (1997) technique widely used among economists has a smoothing method to receive a smooth estimate of the long-term trend component of a series. Technically, they consider a given time series $y_t$, which is seasonally
adjusted, $g_t$ is the sum of a growth component, which varies ‘smoothly’ over time, and a cyclical component $c_t$:

$$y_t = g_t + c_t \text{ for } t = 1, 2, ..., T. \quad \ldots \ldots (3.7)$$

Their measure of the smoothness of the $\{g_t\}$ path is the sum of the squares of its second difference. The $c_t$ is deviation from $g_t$ but their average is near zero over long time periods. These considerations lead to the following programming problem for determining the growth components:

$$\min_{g_t} \left[ \sum_{t=1}^{T} c_t^2 + \lambda \sum_{t=1}^{T} ((g_t - g_{t-1}) - (g_{t-1} - g_{t-2}))^2 \right] \quad \ldots \ldots (3.8)$$

where, $c_t = y_t - g_t$, the parameter $\lambda$ is a positive number, which penalises variability in the growth component series. The larger the value of $\lambda$, the smoother is the solution series. For a sufficiently large $\lambda$, at the optimum all the $g_{t+1} - g_t$ must be arbitrarily near some constant $\beta$ and therefore the $g_t$ arbitrarily near $g_0 + \beta t$. This implies that the limit of solutions to program the function as $\lambda$ approaches infinity is the least squares fit of a linear time trend model.

### 3.3 Factors Determining FDI

The main motivation behind this research is to test if exchange rate levels and its uncertainty deter FDI in India. In addition there are other factors such as market size, inflation rate, lending interest rate, trade openness, agglomeration effect and wealth effect play an important role. These factors motivate the foreign investor to take decision on investing in foreign country. Table - 3.1 gives the summary of empirical reviews on factors determining FDI.
### TABLE - 3.1
SUMMARY OF LITERATURE REVIEW ON
FACTORS DETERMINING FDI

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Variables</th>
<th>Author</th>
<th>Effects on FDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Market Size</td>
<td>Schneider and Frey (1985); Singh and Jun (1996); Billington (1999);</td>
<td>+ve</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cheng and Kwan (2000); Chakrabarti (2001); Moosa (2001); Aggarwal</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>(2005); Pärletun (2008); and Ang (2008)</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Trade Openness</td>
<td>Kravis and Lipsey 1982; Culem 1988; Edwards 1990; Wheeler and</td>
<td>+ve</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mody 1992; Akhter 1993; Gastanaga et. al. 1998; Edward and Savastano</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2000); Chakrabarti (2001); Garibaldi, et. al. (2001); Lim 2001;</td>
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<tr>
<td></td>
<td></td>
<td>Asiedou 2002; Akinkugbe 2003; Jensen 2003; Jordaan 2004; and Pärletun</td>
<td>-ve</td>
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<tr>
<td></td>
<td></td>
<td>2008; Sun, et. al. (2002); and Schmitz and Bieri (1972)</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Agglomeration Effect</td>
<td>Wheeler and Moody (1992); Amirahmadi and Wu (1994); Head, et. al.</td>
<td>+ve</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1995); Head and Ries (1996); Cheng and Kwang (2000); and He (2003)</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Inflation Rate</td>
<td>Schneider and Frey (1985); Rodrik (1996); Fisher and Sahay (1996);</td>
<td>-ve</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Garibaldi, et. al. (2001); Trevino, et. al. (2002); Fisher and Sahay</td>
<td></td>
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<td></td>
<td></td>
<td>(2000); and Estrin, et. al. (1997)</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Lending Interest Rate</td>
<td>Agrawal (2000)</td>
<td>-ve</td>
</tr>
</tbody>
</table>

A brief description of the selected factors is as follows:

**a) Market size:** A number of studies emphasized importance of size of market and its growth in attracting FDI. In countries with large markets, the stock of FDI (especially horizontal) is expected to be large, since market size is a measure of market demand in the country. This is particularly true when the foreign country allows exploitation of economies of scale for import-substituting investment (Aggarwal 2005).
Chakrabarti (2001) stated that the market-size hypothesis supported the idea that a large market is required for efficient utilization of resources and exploitation of economies of scale. That is, as the market-size grows to some critical value, FDI will start to increase thereafter with its further expansion. Moosa (2001) extended this further by suggesting that market size allows for the specialization of the factors of production, and thereby, cost minimization. Studies on the empirical determinants of FDI routinely include GDP as a predictor.

b) Trade openness: The coefficient on openness to trade is expected to have a positive sign, because the more open a country is to trade flows, the more open the investment environment tends to be. This is because a country that imports and exports will have economic stability which is attractive to firms, due to less risk associated with investing in that location. That being the case, a country’s openness to trade should be an indicator of policy makers’ perceptions that linkages to the world economy have a positive effect on growth and development, and that additional FDI would be beneficial. While greater trade barriers could increase FDI if the investment is tariff-jumping or market-seeking motive, they may decrease FDI if the investment is meant to serve as an export-oriented FDI. Edward and Savastano (2000) stated that other things remaining unchanged, greater openness to trade tends to avert undue pressure for the appreciation of the real exchange rate.

c) Agglomeration effect: Foreign investors may be attracted to countries with an existing concentration of other foreign investors. In this case, investment decisions by others are seen as a good signal of favourable conditions and to invest there to reduce uncertainty.³

³ The term ‘agglomeration economies’ is often applied to this situation (Campos and Kinoshita 2003).
Agglomeration economies emerge when there are benefits from locating near other economic units because of positive externalities. Theoretical literature identifies three sources of positive externalities that lead to the spatial clustering of investors. First, technology spill-overs can be shared among foreign investors among various industries. This knowledge can be passed on to other foreign firms by informal communication. To benefit from such spill-overs, foreign firms have to locate close to each other; Second, industry-specific localization arises when firms in the same industry draw on a shared pool of skilled labor and specialized input suppliers; and third, the theory of new economic geography emphasizes backward and forward linkages as a source of agglomeration.

d) Wealth effect: Increased stock market growth could discourage inward FDI through a higher initial cost of purchase or could induce FDI, since higher share prices could be taken as an indication of higher profitability levels in the foreign market. Froot and Stein (1991) argued that depreciation of the foreign country currency against the home currency increases relative wealth of foreigners; and may therefore increase the attractiveness of the foreign country for FDI. Thus foreign firms would be able to acquire assets relatively cheaper in the foreign country. Dewenter (1995) and Kogut and Chang (1996) also tested the effect of wealth effect on FDI when exchange rate depreciates. Relatively higher levels of foreign wealth compared to the foreign country would be associated with higher levels of FDI inflows into the foreign country.

e) Inflation rate: It can be argued that if foreign investors are risk-averse (or even risk-neutral), a higher inflation rate may lead to a reduction in FDI in the foreign country, because investors will not risk profits expected from investment. As long as there is uncertainty, foreign investors would demand a high price to cover their exposure to inflation risks, and this in turn, would decrease the volume of investment.
Foreign investor transferring profits to their countries would benefit if inflation rate in their countries is high, since the currency would have more value when converted to domestic currencies. In this case, foreign investors' profits are higher as a result of the appreciated exchange rates.

On the other hand, if inflation is high in the foreign country, then the price of goods implying in the foreign country increases, which means that costs would be greater due to higher prices. Thus, inflation in the foreign country is likely to negatively impact the investment decisions of (MNCs), especially of those who plan to raise capital in the domestic market. Also, high inflation, like exchange rate volatility, could be a reflection of poor macroeconomic conditions. Thus, to encourage investment, stability of inflation rate is important.

**f) Lending interest rate:** Most of the explanatory variables are straight forward, except interest rate parity that needs attention. Interest rate parity theorem describes the arbitrage link between interest rates and the difference between the spot and forward exchange rate. The coefficient on lending interest rates is expected to have a similar effect as exchange rates. As the lending interest rate increases, the costs of investing in India increases, thus Indian multinationals would tend to look for an alternative country for investment.

Agrawal (2000) identified that higher the level of interest rate the lower would be the level of inward FDI, the present research expects that at high interest rates in the home market, more firms would seek to operate in other locations. This is also consistent with the logic of investment development path model. In more developed markets, interest rates applicable to private investment are normally low, thus encouraging firms to produce locally.
3.3.1 Model specification

On the basis of the theoretical background the following model is formulated to examine the impact of exchange rate levels and its volatility along with other factors determining FDI inflows in India. In formal terms, the model is formulated as follows:

\[ \Delta FDI_t = \alpha + \sum_{j=1}^{p} \lambda_j \Delta RER_t + \sum_{j=1}^{n} \delta_j \Delta VOL_t + \sum_{j=1}^{m} \gamma_j \Delta FDI_{t-j} + \beta_1 \Delta GDP_t + \beta_2 \Delta OPEN_t + \beta_3 \Delta INFL_t + \beta_4 \Delta LR_t + \beta_5 \Delta SM_t + \epsilon_t \]  

... (3.9)

where, \( \Delta \) denotes first difference operator; \( p, n, m \) are the optimal lags; \( FDI_t \) is inflows of Foreign Direct Investment; \( RER_t \) denotes real effective exchange rate; \( VOL_t \) is the volatility measure for exchange rate; \( GDP_t \) is Gross Domestic Product set as a proxy for market size; \( OPEN_t \) is the indicator of openness of trade; \( INFL_t \) is inflation rate; and \( LR_t \) is lending interest rate. Lag of \( FDI \) denotes agglomeration effect, and \( SM_t \) is India’s stock market growth. It is anticipated that \( \lambda_j < 0, \delta_j < 0, \gamma_j > 0, \beta_1 > 0, \beta_2 < 0, \beta_3 < 0, \beta_4 > 0 \) while the sign of \( \beta_2 \) is theoretically ambiguous.

3.4 Autoregressive Distributed Lag Model

Supplementary to the preliminary model specification, the study also attempts to examine the long run relationships using cointegration techniques. The purpose is to find out whether exchange rate levels and its volatility have any short-run and long-run effect on FDI, besides identifying the factors determining foreign decision to invest in India.

There are two primary approaches used to examine the existence of long-run relationship among variables. The first approach is two-step residual-based test for the null of non-cointegration by Engle and Granger (1987) and the fully modified
Ordinary Least Square (OLS) procedures of Phillips and Hansen (1990), and the second approach is the system-based reduced rank regression by Johansen (1988), Johansen and Juselius (1990) and Johansen’s (1995) full information maximum likelihood technique. Both approaches concentrate on cases in which the underlying variables are integrated of order one $I(1)$ and sample size should be large enough.

To overcome this difficulties, a recent single cointegration approach known as autoregressive-distributed lag (ARDL) framework has been developed by Pesaran Shin and Smith (see Pesaran and Pesaran 1997; Pesaran and Shin 1999; and Pesaran et. al. 2001). They applied bounds testing procedure to test for the existence of a long-run linear relationship, when the orders of integration of the underlying regressors are not known with certainty.

The interest in ARDL model are for the following reasons: i) they provide a convenient way to deal with long-run relationships by focusing on the dynamics of one single equation, where the long-run relationship and the short-run dynamics are estimated jointly, ii) the present study is dealing with small sample size$^4$ consist of 48 observation. Hence, ARDL model is more appropriate to overcome the difficulties of small sample size. iii) the variables used in the study are in mixed order with the integration of order zero $I(0)$ and one $I(1)$. Hence, ARDL model make it possible to deal with variables that are of different order of integration. iv) the UECM is likely to have better statistical properties than the two-step Engle–Granger method because it does not push the short-run dynamics into the residual terms (Pattichis 1999; and

$^4$ Several studies have applied the ARDL model to relatively small sample sizes for instance (Gounder 1999 and 2002) and Pattichis (1999) applied it to for 20 observations, Tang (2001) for 25 observations, Tang (2002) for 26 observations, Tang and Nair (2002) for 29 observations.
Banerjee et. al. 1998). v) All variables are assumed to be endogenous. And vi) In ARDL method different variables have differing optimal number of lags.

The ARDL procedure involves two stages. The first stage is to establish the existence of a long-run relationship. Once a long-run relationship has been established, a two-step procedure is used in estimating the long-run relationship. The ARDL approach for the initial investigation of the existence of long-run relationship can be predicted by estimating the short-run and long-run parameters using the following model:

\[
\Delta FDI_t = \alpha + \sum_{i=1}^{l} \beta_i \Delta RER_t + \sum_{i=0}^{u} \chi_i \Delta VOL_t + \sum_{i=0}^{m} \delta_i \Delta GDP_t + \sum_{i=0}^{r} \eta_i \Delta OPEN_t + \sum_{i=0}^{v} \phi_i \Delta FDI_{t-i} + \\
\sum_{i=0}^{s} \pi_i \Delta INF_t + \sum_{i=0}^{o} \theta_i \Delta LR_t + \sum_{i=0}^{n} \gamma_i \Delta SM_t + \lambda_0 \Delta GDP + \lambda_1 \Delta RER + \lambda_2 \Delta VOL + \lambda_3 \Delta INF + \lambda_4 \Delta LR + \epsilon_t
\]

where, the parameter \( \lambda_i \), where \( i=1,2,\ldots,8 \), is the corresponding long-run multipliers; \( l, m, n, o, r, s, u, v \) are the optimum lag of respective variables; and the parameters \( \beta_i, \chi_i, \tau_i, \eta_i, \phi_i, \pi_i, \theta_i, \gamma_i \) are the short-run dynamic coefficients of the underlying ARDL model. The F tests are used for testing the existence of long-run relationships. The null hypothesis for no cointegration amongst the variables in equation (3.9) is

\[
H_0 : \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = \lambda_6 = \lambda_7 = \lambda_8 = 0
\]

against the alternative

\[
H_1 : \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = \lambda_6 = \lambda_7 = \lambda_8 \neq 0
\]

is tested by computing F-statistic.

The F test has a non-standard distribution which depends upon, (i) whether the variables included in the ARDL model are I(0) or I(1), (ii) the number of regressors, and (iii) whether the ARDL model contains an intercept and/or a trend. Thus, Pesaran, et. al. (2001) compute two sets of critical values for a given significance.

\(^5\) For instance, Johansen cointegration technique concern with the decisions regarding the number of endogenous and exogenous variables to be included, the treatment of deterministic elements, the order of VAR and the optimal number of lags to be specified. But generally, the empirical results are very sensitive to the method and various alternative choices are available in the estimation procedure. ARDL avoids concerning the choices mentioned above.
level. One set assumes that all variables are I(0) and the other set assumes they are all I(1). If the computed F-statistic exceeds the upper critical bounds value, then the H₀ is rejected. If the F-statistic falls into the bounds, then the test becomes inconclusive. Lastly, if the F-statistic is below the lower critical bounds value, it implies no cointegration.

After the existence of cointegration, an augmented form of Granger causality test involving the error-correction term is formulated in a multivariate pᵗʰ order vector error-correction model (VECM) using an appropriate lag selection criterion. The asymptotic variance of the long-run estimators obtained by OLS estimation of equation (3.9) can be computed by means of the delta-method, which involves complicated computational procedures (Pesaran and Pesaran 1997). Fortunately, a statistical package (Microfit 4.0⁷) provides this option for single equation estimation. Alternatively, a variant of the error-correction form can be estimated through instrumental variables.

Once the cointegration is confirmed, an augmented form of Granger causality test involving error-correction model (ECM) using an appropriate lag selection criterion as follows:

\[
\Delta FDI_t = \alpha + \sum_{j=0}^{\infty} \beta_j RER_{t-j} + \sum_{j=0}^{\infty} \chi_j VOL_{t-j} + \sum_{j=0}^{\infty} \delta_j GDP_{t-j} + \sum_{j=0}^{\infty} \eta_j OPEN_{t-j} + \sum_{j=0}^{\infty} \phi_j FDI_{t-j} + \sum_{i=0}^{\infty} \pi_i INFL_{t-i} + \sum_{i=0}^{\infty} \theta_i LR_{t-i} + \sum_{i=0}^{\infty} \varphi_i SM_{t-i} + \lambda_1 FDI_{t-i} + \lambda_2 RER_{t-i} + \lambda_3 VOL_{t-i} + \lambda_4 GDP_{t-i} + \ldots (3.11)
\]

\[
\lambda_5 OPEN_{t-i} + \lambda_6 INFL_{t-i} + \lambda_7 LR_{t-i} + \lambda_8 SM_{t-i} + \gamma ECM_{t-i} + \epsilon_t
\]

---

⁶ Given the number of variables m and setting the maximum order of lags of independent and dependent variables equal to n, then a total of \((n+1)^m\) different ARDL models are run by comparing the maximized values of the log-likelihood functions. Later, select the final model which maximize the above mentioned selection criteria. Akaike Information Criterion (AIC) is used for optimal model selection.

⁷ Microfit 4.0 is interactive user-friendly econometric software that is mostly used by economist to analyse micro and macro variables which is developed by Pesaran and Pesaran (1997).
where, $\gamma$ is the speed of adjustment parameter; and $ECM_{t-1}$ is the residual that are obtained from the estimated cointegration model of equation (3.9).

In addition, to evaluate the parameter stability in the models the study graphically plotted cumulative residual sum of square (CUSUM) and CUSUM square tests and forecast error test. Bahmani-Oskooee and Brooks (1999) opined that the estimated parameters derived from the error correction model may not be stable. Since unstable parameters can result in model mis-specification, it which has the potential to bias the result. Therefore, stability tests like the cumulative sum of recursive residuals (CUSUM) and the CUSUM of square (CUSUMSQ) tests proposed by Brown, et. al. (1975) are important to find the stability of parameter. These statistics are updated recursively and plotted against the breakpoints of the model. If the plot of these statistics fall inside the critical bounds of five percent significance, then the coefficients of a given regression are considered as stable. These tests incorporate the short-run dynamics to the long-run through residuals.

In addition to stability test, a simple dynamic forecast technique is also applied to capture the upswing and downswing movement of inflow and outflow of FDI, starting from the first period in the forecast sample to the last period.