CHAPTER 3

OBJECTIVES, DATA SOURCE, RESEARCH METHODOLOGY, SIGNIFICANCE AND LIMITATIONS OF THE STUDY
This chapter contains objectives, data source, research methodology, significance and limitations of the study.

3.1 Objectives of the Study

The principal objective of the present study was to examine the impact of globalisation ushered thorough a phenomenal growth of technology and knowledge on the technological regime of a country like India. In order carry out such investigation the study tried to underpin (a) the rationality behind assessing the traits of India’s technology regime undergoing change in the context of the liberalisation of the economy with reference to India's manufacturing sector.

(b) Secondly, the study also intended to examine the impact of globalisation on India’s technology regime in a macroeconomic perspective. In order to do so, the impact of the import of technology by India on national expenditure on R&D and the impact of R&D activity on technology intensive exports were studied empirically.

(c) The third objective of the study was to evaluate how, after liberalisation, technological innovation and adoption measured by R&D intensity (R&D expenditure as proportion of sales) was influenced by size of the manufacturing industry (measured by sales turnover), outward orientation measured by earning in foreign exchange(as proportion of sales) and outward orientation measured by exports f.o.b.(as proportion of sales), import intensity of embodied technology(import of capital goods as proportion of sales) and import intensity of disembodied technology(payment of royalties, technical fees etc., by domestic firms abroad as proportion of sales). This was done in the perspective of India’s manufacturing industries in an aggregative framework.

(d) The fourth objective of the study was to examine the impact of liberalisation on India’s technology regime at the disaggregated level. In order to accomplish this, factors influencing the R&D Intensity of India’s manufacturing firms were explored and the relative importance of the factors were assessed empirically.
3.2. Data Source

The data regarding the import of technology in respect of the Indian economy in embodied form (import of capital goods) in current prices for the period 1980-81 to 2007-2008 were obtained from the Handbook of Statistics of the Indian Economy: 2010-11, Reserve Bank of India.

The data relating to the national expenditure on R&D in current prices were obtained from the Research and Development Statistics: 2007-08- National Science and Technology Management Information System; Department of Science and Technology; Government of India.


The data regarding the exports of technology intensive exports from India were calculated from the India's imports in Handbook of Statistics of Indian Economy: 2010-11(RBI) and Economic Survey, Government of India: 2010-11 based upon OECD classification of industries according to which Low technology(LT) category includes (a) Food, beverages & tobacco products, (b) Textiles, leather & footwear, (c) Wood, paper & paper products and (d) Rubber & plastic products; Medium-Low Technology(MLT) category includes (a)Other non-metallic mineral products, (b) Cement & glass, (c) Basic metal & metal products, (d) Chemicals excluding pharmaceuticals and (e) Electrical machinery; Medium-High technology category(MHT) includes (a) Non-electrical machinery and (b) Transport equipments; High Technology(HT)category includes (a)Pharmaceuticals and (b) Electronics.

R&D intensity (RDI) was defined as the R&D expenditure as proportion of sales turnover, outward orientation-1(OOR-1) was expressed as the earnings in foreign exchange as proportion of sales turnover, outward orientation-2(OOR-2) was defined as the exports (f.o.b.) as proportion of sales turnover. The import of
disembodied technology intensity (DTI) was expressed as the payments of royalty and technical fees as proportion of sales turnover and the import of embodied technology intensity (ETI) was defined as the import of capital goods as proportion of sales turnover and TECHIM denoted the technology import intensity which was the sum of embodied and disembodied technology import as proportion of sales.

The Capitaline Corporate Database of Capital Market Publishers(I) Ltd., Mumbai, was used to obtain data for the industries, namely, Automobile, Cement, Chemicals, Food Processing, Electric Equipment, Electronics, Engineering, Personal Care, Pharmaceuticals, Refineries, Software, Steel, Telecommunications and Textiles regarding annual sales turnover, R&D expenditure, foreign exchange earnings, exports (f.o.b.), imports of raw materials, spares and finished goods (c.i.f.), payments of royalty and technical fees and import of capital goods by the industries for the period 1996-2009. All these data were expressed in Rs. crores.

The Capitaline Corporate Database was also used to obtain the data on annual sales turnover, R&D expenditure, Profit before tax (PBT), exports of firms (f.o.b) representing Outward Orientation-1, earnings of foreign exchange against sharing knowledge and expertise with foreign firms denoting Outward Orientation-2, import of capital goods representing import of embodied technology (ET), payment of royalty, technical fee, etc. abroad against acquiring knowledge, technical knowhow, etc. representing import of disembodied technology(DT) for the Indian manufacturing firms. R&D, PBT, Outward Orientation-1, Outward Orientation-2, ET and DT were expressed as percentage of annual sales turnover indicating the variables as R&D intensity (RDI), PBTS, OOR-1, OOR-2, ETI and DTI. Market share (MSH) was expressed as the proportion of sales of the respective firms to the sales of the industry. All the items were expressed in Rs. crores. While selecting the firms the objective was to obtain data covering as long a period as possible.
A thorough screening of the database helped in consolidating the data for the following number of firms in connection with the different industries:


3.3. Research Methodology

The compound annual rate of growth of the relevant variables was calculated.

For studying the impact of India’s import of embodied technology on the national expenditure on R&D the variables were transformed into log forms in order to capture how and to what extent one per cent increase in the import of embodied technology makes an impact on the R&D expenditure.

Augmented Dickey-Fuller (ADF) unit root test was done for the relevant variables expressed in log forms to judge whether the regression could be done among them. Pooling all the observations for the pre-reform and the post-reform periods in a single regression equation and introducing intercept and slope dummies the following regression equation was estimated:

\[ \text{LGRD} = \alpha_1 + \alpha_2 \text{LGEMTMP} + \alpha_3 D_1 + \alpha_4 (D_1 \text{LGEMTMP}) + u_i \]

where LGRD was log value of R&D, LGEMTMP was log value of the import of embodied technology, \( \alpha_3 \) was differential intercept and \( \alpha_4 \) was differential slope coefficient, \( D_1 \) and \( (D_1 \text{LGEMTMP}) \) were intercept and slope dummies respectively and \( I = 1, 2, 3, \ldots, 28 \).

And \( D_1 = 0 \) for the values of 1980-1990

\[ = 1 \] for the values of 1991-2007

The same examination of the nature of time series data regarding the disembodied technology import was done and for implicating the impact of the latter on India’s R&D all the observations for the pre-reform and the post-reform periods were pooled in a single regression equation and intercept and slope dummies were introduced for estimating the following regression equation:
LGRD = \( \alpha_1 + \alpha_2 \text{LGDMTMP} + \alpha_3 D_1 + \alpha_4 (D_1 \text{LGDMTMP}) + u_i \)  where

LGRD was log value of R&D, LGDMTMP was log value of the import of disembodied technology, \( \alpha_3 \) was differential intercept and \( \alpha_4 \) was differential slope coefficient, \( D_1 \) and \( (D_1 \text{LGDMTMP}) \) were intercept and slope dummies respectively and \( i=1,2,3,\ldots,28 \).

And \( D_1 = 0 \) for the values of 1980-1990

= 1 for the values of 1991-2007

The nature of time series data regarding the import of technology, which was taken as the sum of embodied and disembodied technology import, was tested through ADF test and then pooling all the observations for the pre-reform and post-reform periods and introducing intercept and slope dummies the following regression was estimated:

LGRD = \( \alpha_1 + \alpha_2 \text{LGTMP} + \alpha_3 D_1 + \alpha_4 (D_1 \text{LGTMP}) + u_i \) where

LGRD was log value of R&D, LGTMP was log value of the import of technology, \( \alpha_3 \) was differential intercept, \( \alpha_4 \) was differential slope coefficient, \( D_1 \) and \( (D_1 \text{LGTMP}) \) were intercept and slope dummies respectively and \( i=1,2,3,\ldots,28 \).

And \( D_1 = 0 \) for the period 1980-1990

= 1 for the period 1991-2007

While studying the impact of R&D on India's exports of High Technology (HT) products the time series data for the log value of the latter was tested through the ADF test and then pooling all the observations for the pre-reform and post-reform periods and introducing intercept and slope dummies the following regression was estimated

LGHT = \( \alpha_1 + \alpha_2 \text{LGRD} + \alpha_3 D_1 + \alpha_4 (D_1 \text{LGRD}) + u_i \) where

log value of HT exports (LGHT) was the dependent and log value of R&D was taken as the explanatory variables and \( D_1 \) and \( D_1 \) (LGRD) were the differential intercept and slope dummies, \( \alpha_3 \) was the differential intercept, \( \alpha_4 \) was the differential slope coefficient and \( i=1,2,3,\ldots,28 \) and
D₁ = 0 for the period 1980-1990
= 1 for the period 1991-2007

In order to explore the impact of globalisation on India’s technology regime in the perspective of the manufacturing industries the study followed two approaches: first, the influence of SIZE and ETI and DTI on RDI of the industries was explored in elasticity terms with the help of log-linear model on the basis of time series data at the industry level for the period 1996-2009 and secondly, in order to capture the influence of outward orientation along with the influence of size of the industry and the import of technology import on RDI a multiple regression analysis was done taking RDI as the dependent variable and ETI, DTI, SIZE, OOR1 and OOR2 as the explanatory variables. The time series covered the period 1996-2009.

While pursuing the first objective the following regression was estimated:

\[ \text{LGRDI} = \alpha + \beta_1 \text{LGSIZE} + \beta_2 \text{LGETI} + \beta_3 \text{LGDTI} + \epsilon \]

where LGRDI, LGETI and LGDTI were R&D intensity, Embodied technology import intensity and Disembodied technology intensity transformed into log values, SIZE was measured by the annual sales turnover of the industry transformed into logarithm and \( \epsilon \) was the error term.

The estimated equation was then used to determine the respective elasticities:

\[ e_1: \text{elasticity of RDI with respect to SIZE (} \delta \log \text{RDI}/\delta \log \text{SIZE}) \]
\[ e_2: \text{elasticity of RDI with respect to ETI (} \delta \log \text{RDI}/\delta \log \text{ETI}) \]
\[ e_3: \text{elasticity of RDI with respect to DTI (} \delta \log \text{RDI}/\delta \log \text{DTI}) \]

In order to explore the second objective the following regression equation was estimated:

\[ \text{RDI} = \alpha + \beta_1 \text{ETI} + \beta_2 \text{DTI} + \beta_3 \text{OOR1} + \beta_4 \text{OOR2} + \beta_5 \text{SIZE} + \epsilon \ldots \text{ (ii)} \]

where the variables had usual interpretation except that SIZE was annual sales turnover of the industry transformed into logarithm and \( \epsilon \) was the error term.
The study attempted to explore the impact of several variables on the R&D intensity of the Indian manufacturing firms belonging to different industries during the period 1996-2009. Accordingly, the following regression equation was estimated:

\[ RDI_{i,t} = \alpha + \beta_1 OOR_{1,i,t} + \beta_2 PBTS_{i,t} + \beta_3 MSH_{i,t} + \beta_4 DTI_{i,t} + \beta_5 ETI_{i,t} + \beta_6 OOR_{2,i,t} + \beta_7 LFSIZE_{i,t} + \mu_{i,t} \]

where

- \( RDI_{i,t} \) = Total R&D expenditure of the \( i \)th firm as proportions of its sales in the \( t \)th year.
- \( OOR_{1,i,t} \) = Earnings of foreign exchange by ith firm on account of royalties, technical fees, dividends etc. from abroad as a proportion of its sales in \( t \)th year.
- \( PBTS_{i,t} \) = Profit margins before tax of ith firm as a proportion of its sales in \( t \)th year.
- \( MSH_{i,t} \) = Ratio of sales of \( i \)th firm to the industry sales in \( t \)th year.
- \( DTI_{i,t} \) = Royalties and technical fee paid abroad by ith firm as a proportion of its sales in \( t \)th year.
- \( ETI_{i,t} \) = Imports of capital goods by ith firm as a proportion of its sales in \( t \)th year.
- \( OOR_{2,i,t} \) = Exports of goods by ith firm(f.o.b) as a proportion of its sales in \( t \)th year.
- \( \mu \) = Error term.

### 3.4. Significance of the study

The main focus of this study was on India’s manufacturing sector. This should be attributed to the longstanding importance of the sector in India’s economy which was discussed in Chapter1 of the study. The relatively declining trend of the agricultural sector in accommodating the pressure of population on it and the heightening importance of the service sector in making contribution to the GDP need a careful scrutiny in a country like India where the surplus population from agriculture could hardly be absorbed into the latter owing to lack of proper
training and education and this called forth an assessment of the position that could be occupied by the manufacturing sector in relieving the pressures upon the economy. In this study an attempt was made in that direction.

Secondly, at the advent of the globalisation the production structure and organisational pattern of the manufacturing industries had undergone several changes. Firms started to realize that in order to be competitive its nature of indulging in mass production has to be replaced by the multiproduct trait and more emphasis would have to be placed on ensuring quality and quick response to customer demand. It is the situation under which innovation registered an indelible mark. No matter whether it is product or process innovation, the central theme is continuous improvement and up gradation of technology that implicates acquisition, adoption and consolidation of knowledge. Firms should no longer be viewed as optimizing agent, rather, they should endeavour to modify the demand for their products and get themselves accustomed to the development of new technologies. Technology is a powerful factor for the growth of the manufacturing sector but, in the context of the changes in the production structures and organisational pattern of the sector that was ushered through globalisation, the concept of technology defined in terms of the production function approach of the neo-classical type could no longer be appropriate. The concept of ‘technology regime’, introduced by the Evolutionary Theory in the hands of Nelson and Winter initially and by the others subsequently appeared to be meaningful and contextual since, according to this concept, technologies should not be defined in terms of a stylized input-output analysis, rather these should best be seen as ‘being linked with other technologies, economic activities and production and user practices and a whole range of institutions forming a technology system’ (Mulder, Reschke and Kemp, 1999). In this study this point was clarified and explained in detail.

Thirdly, where most studied concentrated on the issues pertaining to the productivity of the Indian manufacturing sector, the present study, unveiled the emerging nature of India’s technological regime after the liberalisation of the economy in 1991. The main components of the regime defined in terms of acquisition and adoption of new technology and technological innovation were
discussed in the context of Indian scenario. Moreover, the association of the technological regime of India with the country’s manufacturing sector was studied in analytical framework. After liberalisation of the economy the scope was widened for the import of technology, exports of goods, earnings of foreign exchange through royalties, etc. and a vast market with pronounced competitive elements. Accordingly, in order to gain competitive edge over others the need for technological innovation was aggravated calling forth enhanced R&D expenditure by the government as well as the private sector. All these necessitated a review of the trend of import of technology, R&D expenditure incurred, exports of goods, earnings of foreign exchange by the government, industries and the firms which was accommodated in the study at the macroeconomic perspective.

Fourthly, the study tried to explore the factors influencing the R&D expenditure of the government, industries and the firms since expenditure incurred on R&D was a better proxy for the technology adoption, acquisition and absorption of new technology.

Fifthly, the treatment of industry and the firm separately in the study was done in view of the fact that in evolutionary theory decision rules made within the firms are viewed as a legacy from the firms’ past. These rules are appropriate to the circumstances within which the firms find themselves. These are not responsive to the situations which the firms encounter irregularly. Firms expand or contract facing disequilibria no matter whether industries are near equilibrium. Innovation, in evolutionary theory, is treated as stochastic and as variable across firms (Nelson and Winter, 1982). Moreover, it was pointed out in another study that the industries, in evolutionary theory, could not be treated as aggregation of firms ‘because firms are a combination, even compromise, of internalizing and externalizing tendencies’ (Bloch and Finch, 2007).

### 3.5. Limitations of the Study

This study was based upon data for the pre-reform and post-reform periods in respect of analysing the impact of technology import on R&D expenditure and the impact of the latter on technology intensive exports in India’s macroeconomic
perspective. But while discussing the impact of various factors on the R&D expenditure of India’s manufacturing sector both at the industry and firm levels the study had to remain contented with the data pertaining to the post-reform period only because time series data for the pre-reform period was not systematically available. Therefore, for studying the changing nature of India’s technology regime in the aggregative and disaggregated cases comparison between pre-reform and post-reform scenario could not be made.

While selecting the firms belonging to different industries the main focus of the study was to collect data for as long a period as possible so that while pursuing regressing analysis the degrees of freedom should not be minimum. In doing so the study was left with the selection of 98 firms only.

Lastly, the number of firms selected in the sample was not uniform. The reason for this was that either the information was not provided by firms themselves to the Capitaline Corporate Databases or because of a lag in the compilation of data.