CHAPTER-III
METHODOLOGY AND DATABASE

3.1 INTRODUCTION

Rationale of the various data sources, choice and construction of various variables and the techniques adopted for the analysis are the major components encompass methodology. Having discussed the theoretical underpinning adopted in the present study in the first two chapters of the study, the present chapter presents the basic methodology adopted in the study.

The chapter begins with describing the period of the study in section 3.2. The rationale of the various secondary data sources used in the thesis is presented in section 3.3. Section 3.4 presents the rationale of various methods adopted for the analysis. In section 3.5, the construction of various variables is discussed followed by conclusion in section 3.6.

3.2 PERIOD OF STUDY

The study covers the period from 1980-81 to 2005-06. To ascertain the impact of alternative policies of trade and technology on industrial growth, we have divided the whole period into two sub-periods: 1980-81 to 1991-92 (pre-reform period) and 1992-93 to 2005-06 (post-reform period). Since, India adopted economic reforms in 1991, a decade before the initiation of reforms (starting from 1980-81) is worth comparing with the period after the reforms\(^{16}\).

3.3 DATABASE

With around 2/3\(^{rd}\) of value added in the Indian manufacturing industries emerging from the organized manufacturing industries (Nagaraj, 2003), the issue of finding the source of its growth led to the natural choice for this sector in the present analysis. Organized or registered manufacturing industries consists of all factories registered under Sections 2m(i) and 2m(ii) of the Factories Act, 1948 i.e. those factories employing 10 or more workers using power; and those employing 20 or more workers without using power.

\(^{16}\) At the time of initiating the study, the data for manufacturing industries was available up to 2005-06.
The basic data source for the time series data on variables such as value added, capital, employment for the organized manufacturing industries is Annual Survey of Industries (ASI) published by Central Statistical Organization (CSO). The ASI classifies industries on the basis of various industrial codes and names as given by United Nations Statistical Division (UNSD). This classification is subject to frequent changes from time to time. Therefore, the study which is based on ASI database has to attend the changing classification to make the data series consistent and comparable over time. It needs to be mentioned here that this difficult task of preparation of consistent data series for the various variables of manufacturing industries has been undertaken by Economic and Political Weekly Research Foundation (EPWRF). Therefore, in this study, we have used data released by EPWRF which is drawn from its electronic database.

Since, EPWRF dataset is available only till 2003-04, so for the years 2004-05 and 2005-06, the data was taken directly from ASI (CSO). An attempt was made to adjust data for ensuring consistency with the EPWRF database.

This study fundamentally deals with the analysis of sources of technological progress and its transformation process. There arises the need to supplement data relating to research and development (R&D) expenditure in the manufacturing industries and international trade.

Data pertaining to R&D expenditure in industry is collected from the various issues of Research and Development in Industry, Ministry of Science and Technology (MOST), New Delhi, Government of India for the years 1980-81 to 2003-04. For the years 2004-05 and later, the data is taken from the issues of Research and Development Statistics, Ministry of Science and Technology, Government of India. The concordance is done for NIC’04 and the R&D in industry (Appendix IV). The

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17 During the period of the analysis NICs changed several times. NIC 1970 functioned till 1988-89; NIC 1987 was for the period 1989-90 to 1997-98; while NIC 1998 was for the period 1998-99 to 2003-04. Moreover, industrial classification changed another time to NIC 2004 for 2003-04 to 2005-06. But on comparing the industrial codes at the 3-digit level of disaggregation for NIC 1998 and NIC 2004, no change was found therein and the data series was regarded to base on NIC 2004.
National Science and Technology Management Information System (NSTMIS) Division of Department of Science and Technology (DST) have been undertaking biennial national surveys on a regular basis to collect this data.

Secondly, UN-COMTRADE\textsuperscript{18} from World Integrated Trade Solutions (WITS) was used for collecting the data on trade. International Standard Industrial Classification (ISIC) rev 3 is compatible with the NIC’04 classification for the Indian manufacturing industries. But this data series for the imports and exports variables was available after 1988. So for the earlier years ISIC rev 2 with nomenclature Standard International Trade Classification (SITC) rev 2 was used. The concordance for trade data is presented in Appendix IV.

Further, the data on R&D expenditure by the manufacturing industries done by the 30\textsuperscript{19} OECD countries was required that is compatible with the data on various variables of the manufacturing industries. Thus, the data was collected from OECD STAN (Structural Analysis) database which provides the data at comparable 3-digit manufacturing industries.

Suitable deflators for value added, capital and R&D expenditure is taken from Index Number of Wholesale Prices in India, prepared by the Office of the Economic Advisor, Ministry of Industry, Government of India. While to deflate the export and import data series, the export unit index and import unit index, respectively is drawn from International Monetary Fund – International Financial Statistics (IMF-IFS).

With the objective to analyze the extent of technological progress and its transformation process, we classify the industries into four technology intensive industrial sub-groups [High technology (HT), Medium-High technology (MHT), Medium-Low technology (MLT) and Low-technology (LT)] based industrial classification provided by the Organization for Economic Cooperation and Development (OECD), 2007.

\textsuperscript{18} The COMTRADE database is the most comprehensive source of trade statistics brought out by World Bank and United Nations Statistical Division (UNSD).

\textsuperscript{19} Amongst the 30 OECD countries, R&D expenditure in industry data is not available for seven OECD countries namely Belgium, Finland, France, Luxembourg, Mexico, Sweden and Switzerland. Further, R&D in industry data for Austria is available after 2002; Czech Republic after 1993; Germany after 1991; Hungary after 1994; Iceland after 1993; Italy after 1991; Korea after 1995; Poland after 1994; Portugal after 1988; Slovak Republic after 1993; and Turkey after 1990.
The study is primarily aimed at doing the analysis at the three-digit level of disaggregation, but while classifying the industries according to OECD (2007) technological classification, it was found that one industry – pharmaceuticals (NIC’04 code 2423) falls in the High technology sub-group, while its 3-digit sub-group ‘other chemical products’ (NIC’04 code 242) is a part of the medium-high technology (M-HT) sub-group. Thus, a separate series was developed for pharmaceuticals (NIC’04 code 2423) at the 4-digit level of disaggregation. Again to avoid double counting in the dataset, the values for the variables for the pharmaceuticals (NIC’04 code 2423) was subtracted from the values of the variables for the ‘other chemical products’ (NIC’04 code 242).

Thus, the study is based on the data for 59 three-digit industries and one four digit industry. But out of the total 60 industries, the consistent data for all the chosen variables was only available for 51 industries. Thus, the industries with the NIC’04 codes 182, 223, 233, 243, 273, 315, 319, 342, 343 (Appendix I) are excluded from the analysis where explicitly stated.

3.4 METHODS OF ANALYSIS

In the present section, the various techniques used in the study are presented which are also accompanied by the rationale of their choice.

3.4.1 Structural Break

Has there being any turning points for the Indian manufacturing industries since 1980s? When the manufacturing industries did witnessed acceleration in its growth rate? The estimation of timing regarding the growth rate of manufacturing industries could probable throw some light on the issue of debate regarding the adoption of reforms during the early 1990s.

In seeking to find turning point in the industrial growth, or structural breaks in the pace of its growth, the following methodological issues arise. There are usually two major approaches concerning the identification of structural break date in the data

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20 The concordance for ‘pharmaceutical’ is done for the four different NIC classifications – as according to NIC 1970, pharmaceutical has the industrial code of 313; for NIC 1987, it is 304 and subsequently for NIC 1998 and NIC 2004, it is 2423.
series. The first being to identify the break date using some econometric technique which cause an inflexion in the graph series while the second being due to the occurrence of some exogenous event expected to cause the structural change.

Following the methodology by Bai and Parron\textsuperscript{21} (1998), Balakrishnan and Parameswaran (2007) found 1994-95 as the break date in case for the registered manufacturing industries in India. However, they specifically address that “an element of judgement is involved here” regarding “the choice of interval length”\textsuperscript{22}.

The other most comprehensive study on the subject was that by Wallack (2003), wherein she used the F-tests for all possible years and then selects the most statistically significant year as the break date. Regarding the organized manufacturing industries, however, she does not find any break after 1964. But she herself emphasised that the results are “not robust” since the other years have the F-statistics close to the maximum values.

However, in other comprehensive study by Rodrik and Subramanian (2004) using the methodology by Bai and Parron (1998) did not find any structural break in India’s economic growth after 1980 while the study by Nayyar (2008) emphasised that the structural break of early 1950s is much more significant for both polity and economy of India than any such break that followed it.

Since no clear consensus have emerged from the literature on the subject in determining the structural break date for the organized manufacturing industries in India; an attempt is made in the present study to determine such date afresh using ‘Cusum of square’ test. This test was based on the methodology developed by Brown et al. (1975) where the recursive residuals are estimated from the regression analysis to test the parameter consistency (Johnston and DiNardo, 1997). However, the visual inspection of the graph suggests the parameter constancy or the reverse (ibid). The following Figure 3.1 presents the result of the structural break analysis for the Indian manufacturing industries for the period 1980-81 to 2005-06.

\textsuperscript{21} The break dates are estimated as the minimizers of sum of squared residuals but after assuming the length of the segments and thus, the number of break points.

\textsuperscript{22} However, they regarded that the estimates are invariant to the length = 4,5, or 8 only.
Figure 3.1. Estimation of Structural Break

a. CUSUM Squared (Manufacturing Industries)

b. CUSUM Squared (HT Industries)

c. CUSUM Squared (MHT Industries)

d. CUSUM Squared (MLT Industries)

e. CUSUM Squared (LT Industries)
The Figure 3.1 shows the structural break for the organized manufacturing industries and its various sub-sectors. The Figure 3.1.a shows 1993-94 to be the break-date for the organized manufacturing industries, whereas for the HT industries (Figure 3.1.b), MHT industries (Figure 3.1.c), MLT industries (Figure 3.1.d), LT industries (Figure 3.1.e), the structural break year came to be 1985-86, 1989-90, 1986-87 and 1992-93, respectively. This reveals that it is not possible to regard one unanimous structural break-date in the series with respect to the industrial sector. Further, it points to the fact that the break-date using econometrics analysis is different for each industrial sub-group and even for individual industries (Mehta, 2011).

However, based on the literature surveyed on the subject and the inconclusive results accrued by the present exercise, it seems plausible that the exogenous factor could be regarded as the basis for dividing the data series, which in the present case and issue would be the economic reforms of 1991. So the series is divided into pre-reform period from 1980-81 to 1991-92 and post-reform period from 1992-93 to 2005-06.

3.4.2 Semi-Logarithmic Time Trends

For estimating the trends growth rate for the period 1980-81 to 2005-06 for the various variables like value added, imports, exports and total factor productivity growth, the following method semi-logarithmic model is used. To begin with the compound interest formula as follows.

\[ Y_t = Y_0 (1+r)^t \]  

where \( Y_t \), \( Y_0 \), \( t \) and \( r \) are dependent variable, initial value, time and compound rate of growth of \( Y \), respectively.

Taking Natural log of (1)  

\[ \log Y_t = \log Y_0 + t \log (1 +r) \]  

Assuming \( \log Y_0 = \beta_1 \) and \( \log (1 +r) = \beta_2 \)  

Equation (2) can be written as  

\[ \log Y_t = \beta_1 + \beta_2 t \]
The linear regression will give the estimate of $\beta_2$. Thus, the compound growth rate, $r$ can be calculated by taking antilog of $\beta_2$ minus 1 and multiplying by 100.

3.4.3. Single Kinked Model

For estimating the trend growth rate for the two sub-periods – pre-reform period (1980-81 to 1991-92) and post-reform period (1992-93 to 2005-06), there are two choices. The first is to estimate both the sub-periods separately using the semi-logarithmic method as already described. But it was found from the study by Goldar and Seth (1989), that using single-kinked method in this situation would provide relatively better results.

In the single-kinked method, the estimation of growth rates in sub-periods of a time-series is done by fitting only one regression equation instead of fitting separate exponential trend lines for the sub-periods. In this method, the intercept and slope dummies are used to yield growth rates for different periods.

Thus, the following log-linear models yield kinked exponential functions was used for the estimation (Boyce, 1986; Goldar and Seth, 1989).

The model can be derived using the following equation.

$$\log Y_1 = a_1 D_1 + a_2 D_2 + (b_1 D_1 + b_2 D_2) t + \mu_1 \quad \ldots \ldots \ldots \ldots (1)$$

where $Y_1$ is real net value added, time $t = 1, \ldots, n$ is broken at point $k$, and $d_j$ is the dummy variable ($j = 1, 2$) which takes the value 1 in the $j$th sub-group and 0 otherwise.

To avoid discontinuity, a linear restriction of interaction of two trend lines at ‘$k$’ is imposed such as

$$a_1 + b_1 k = a_2 + b_2 k \quad \ldots \ldots \ldots \ldots (2)$$

Now substituting in equation (1), the value for $a_2$ and from equation (2) assuming $a_1 D_1 + a_2 D_2 = a_1$, we get

$$\log y_1 = a_1 + b_1 (D_1 t + D_2 k) + b_2 (D_2 t - D_2 k) + \mu_1 \quad \ldots \ldots \ldots \ldots (3)$$

The estimates for $b_1$ and $b_2$ give the exponential growth rate for the two sub-periods.

3.4.4 Structural Transformation Model

For the present study the model is developed which has the manufacturing sector as the unit of analysis in which the particular pattern can be produced by
certain factors as: change in demand, change in investment (fixed capital and R&D), change in demand for exports and change in employment.

The standard linear model can be expressed as

\[ Y_{it} = e^{\alpha_{it}} X_{it}^d e^{\mu_{it}} \]  \(.........(1)\)

where \( Y_{it} \) is the dependent variable for the cross-section industry \( i \) at time \( t \) and \( X_{it}^d \) represents the \( d \)th explanatory variable(s) for unit \( i \) at time \( t \). Since, there are 5 explanatory variables; the linear model takes the form as.

\[ Y_{it} = e^{\alpha_{it}} \cdot FC_{it}^{\beta_f} \cdot EMP_{it}^{\beta_{em}} \cdot EX_{it}^{\beta_{ex}} \cdot OT_{it}^{\beta_o} \cdot RD_{it}^{\beta_r} e^{\mu_{it}} \]  \(.........(2)\)

where:
- \( Y \) (dependent variable) is \( VA_{it}/VA_t \); \( VA \) is net value added;
- \( FC \) is \( FC_{it}/FC_t \); \( FC \) is fixed capital;
- \( EMP \) is \( EMP_{it}/EMP_t \); \( EMP \) is total persons employed;
- \( EX \) is \( EX_{it}/EX_t \); \( EX \) is exports;
- \( OT \) is \( O_{it}/O_t \); \( O \) is total output (as a proxy for demand) and
- \( RD \) is \( RD_{it}/RD_t \); \( RD \) is research and development expenditure (R&D).

A logarithmic transformation of equation (2) yields

\[ y_{it} = \alpha_{it} + \beta_f FC_{it} + \beta_{em} EMP_{it} + \beta_{ex} EX_{it} + \beta_o OT_{it} + \beta_r RD_{it} + \mu_{it} \]  \(.........(3)\)

where lower case indicates logs of the same variables, \( \alpha \) is the constant term while \( \mu_{it} \) is the random disturbance term.

Now, the error structure for the disturbance term can be specified as:

\[ \mu_{it} = \zeta_{it} + \eta_{it} \]  \(.........(4)\)

where \( \zeta_{it} \) is known as the individual effect;

and \( \eta_{it} \) is usual disturbance term.

There are the following two assumptions about the individual effect:
1. Random effect model: \( \zeta_{it} \) is uncorrelated with the \( X_{it} \).
2. Fixed effect model: \( \zeta_{it} \) is correlated with the \( X_{it} \).

The estimation was done by using the following regression analysis process of statistical inference.

**Regression Analysis**

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The study uses two types of regression analyses. The first being the balanced panel dataset, which consists of the same number of observations \((t=1, \ldots, T)\) on each cross-section unit \((i=1, \ldots, N)\), so that the total number of observations becomes \(N \times T\) (Johnston and DiNardo, 1997). Moreover, the panel data estimation deals with the cases where \(N\) is large relative to \(T\) (\(N>T\)). So, based on the double-log model, the analyses begin by assuming \(\mu_{it} \sim iid(0, \sigma^2)\) for all \(i\) and \(t\), that is the errors are homoscedastic and serially uncorrelated. The OLS (ordinary least square), although gave the robust results; but to avoid any bias in the empirical analyses Breush-Pagan statistics is undertaken to identify whether pooled estimator is consistent or not. If the estimated test produces significant \(\chi^2\), it reject the null hypothesis of homoskedasticity. Secondly, Durban-Waston test was used to test the auto-correlation. If, incase both auto-correlation and heteroskedasticity emerges, than the Generalised Least Square (GLS) is used for the analysis after controlling these two discrepancies. Further, to access other options besides OLS to regress the panel dataset; which being to choose between the fixed effect and the random effect model for the study. However, based on the randomness of the environment engulfing the industrial sector over the long period of time, it is hypothesised that the individual effects are uncorrelated to the explanatory variables. However, to solve this dilemma Hausman test is used, if it leads to the insignificant result (prob > chi2 greater than 0.005) the random effect model is used for the analysis and otherwise fixed effects model is used.

However, if the \(N\) is small relative to \(T\) (\(N<T\)), \textit{Time-series and Cross-section} (TSCS) \textit{Analyses} is used for the analyses after controlling for the heteroscedasticity and autocorrelation.

3.4.5 Total Factor Productivity Growth (TFPG):

Total factor productivity growth (TFP) is the residual growth of value-added which is not explained by growth of factor inputs. In other words, it may be defined as the ratio of real output (or real value added) to a weighted sum of inputs used in the production process. It aims at decomposing changes in production due to changes in quantity of inputs used and changes in all the residual factors such as change in technology, capacity utilisation, quality of factor of production, learning by doing etc.
(Trivedi et al., 2000). Thus, it is recognised as a key feature of economic dynamism today (Ahluwalia, 1991).

The following methods have been used in the present study. Growth Accounting method is used to estimate the TFPG and the Stochastic Frontier Approach is used to estimate the extent of efficiency in the manufacturing industries.

3.4.5.1 Growth Accounting Method:

In this approach, different indices are developed based on the implicit assumptions of different production functions along with the two common assumptions of competitive equilibrium and constant returns to scale. In the present study Translog Index is used. The superiority of this method is found in literature (Goldar, 1986; Ahluwalia, 1991; Trivedi et al., 2000). This method have a relatively few assumptions; particularly it does not assume Hicks neutrality or constant elasticity of substitution.

The measure of TFPG, based on a Translog production function in discrete version of continuous Divisia Index, that is Tornqvist Index which takes the following form:

\[ \Delta P(t)/P(t) = \Delta V(t)/V(t) - \left[ \hat{s}_l(t)(\Delta L(t)/L(t)) + \hat{s}_k(t)(\Delta K(t)/K(t)) \right] \]

Where \( \Delta V(t)/V(t) \sim \log [V(t)/V(t)] = \log V(t) - \log V(t-1) \)

\[ \Delta L(t)/L(t) = \log L(t) - \log L(t-1) \]

\[ \Delta K(t)/K(t) = \log K(t) - \log K(t-1) \]

\[ \hat{s}_l(t) = \frac{1}{2} [S_L (t-1) + S_L (t)] \]

\[ \hat{s}_k(t) = \frac{1}{2} [S_K (t-1) + S_K (t)] \]

where \( V, L \) and \( K \) are gross value added, labour (total persons employed) and capital stock.

\( S_L \) is share of labour in value added measured using ‘total emoluments’.

\( S_K \) is share of capital in value added

The TFP index can be constructed from the TFPG series using the following procedure.

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23 In this, the factors of productions are paid the value of their marginal productivity.
24 With the proportionate increase in inputs the output increase in the same proportion.
25 A technical change is Hicks neutral when with the constant capital-labour ratio, the marginal product of capital to that of labour remains constant.
3.4.5.2. Frontier Production Function Approach:

The stochastic production function models as developed independently by Aigner et al. (1977) and Meeusen and van den Broeck (1977) are used for analyzing the panel data by including the parameters that varies over time as developed by Cornwell et al. (1990).

Thus, in the present study, panel data for the organized manufacturing industries is analysed to estimate the Inefficiency Frontier Model as developed by Battese and Coelli (1993) using Frontier 4.1 software. The time-varying model is as follows.

\[
\log y_{it} = \beta_0 t + \beta_1 \log l_{it} + \beta_2 \log k_{it} + \beta_3 t + \epsilon_{it} - U_{it} \\
\epsilon_{it} = V_{it} - U_{it}
\] ........................(1)

where \(\beta_j\) are the partial elasticity of value added, \(y_{it}\) with respect to inputs \(j\) (\(j=1, \ldots, J\)); \(y_{it}\) is the level of value added at the \(t^{th}\) \((t=1,2,\ldots,T)\) observation for the \(i^{th}\) \((i=1,2,\ldots,N)\) industry, vector \(x\) denotes inputs \(j\); \(\epsilon_{it}\) is the error term comprising a random component consists of: \(V_{it}\) which are the random errors assumed to be independent and identically distributed as normal random variables with zero mean and constant variance \(\sigma^2_v\), and is also assumed to be independent of \(U_{it}\); where \(U_{it}\) is the non-negative random variable, associated with technical inefficiency, which is assumed to be independently distributed truncated at zero with variance \(\sigma^2\) and mean \(\zeta_{it}\), that is, \(U_{it}\) are assumed to be the function of \(z_{it}\) and unknown coefficients, \(\delta\).

Thus, the stochastic frontier production function assumes the following form.

\[
\log y_{it} = \beta_0 t + \beta_1 \log l_{it} + \beta_2 \log k_{it} + \beta_3 t + V_{it} - U_{it} \\
\] ........................(2)

where ‘technical inefficiency effects’ are assumed to be defined as the function of \(t\) and square of \(t\), thus defining the ‘time-varying’ \((\tau)\) component following Cornwell et al. (1990).

Thus, the ‘Inefficiency Model’ takes the form as:

\[
U_{it} = \delta_{i} + \delta_{1i} t + \delta_{2i} t^2 \\
\] ........................(3)

where \(y\) is the gross value added

\(l\) is the ‘total persons employed’
k is the ‘capital stock’ calculated through perpetual inventory method (3.6(iv))
U(t) is the function of t and t²
V(t) has the properties as discussed and
β’s and δ’s are the coefficients.
Further, the Technical Efficiency (TE) of the i-th industry in t-th year (TE_{it}) is defined as
\[ TE_{it} = \exp (-U_{it}) \]
Technical efficiency is the ratio of actual output of the industry to its frontier output. So, technical efficiency equals one if the industry has an inefficiency effect equal to zero, otherwise it is less than one.

3.4.6 Technology Spillover Model
For estimating the relationship between total factor productivity (TFP) and source of technology – indigenous R&D expenditure or technology spillover from imports, the following model is developed which takes the form as:
\[ \log TFP_{it} = \alpha_{it} + \beta_1 \log S^d_{it} + \beta_2 \log FS_{it} + \epsilon_{it} \] ....1
where TFP is the total factor productivity;
S^d is the industry’s own R&D capital stock;
FS is the international import weighted knowledge spillovers;
ε is the random disturbance term; and i and t index industries and time periods.
Now, the error structure for the disturbance term can be specified as:
\[ \mu_{it} = \zeta_i + \eta_{it} \] .........(4)
where ζ_i is known as the individual effect;
and η_{it} is usual disturbance term.
There are the following two assumptions about the individual effect:
1. Random effect model: ζ_i is uncorrelated with the X_{it}.
2. Fixed effect model: ζ_i is correlated with the X_{it}.
The regression analysis as discussed earlier is used for estimation.

3.5 VARIABLES
(i) Output: An important choice in the measurement of output is between value added and gross output. If the latter is chosen then it becomes necessary to
specify the production function in terms of labour, capital and material. Next, the choice between the ‘net’ and ‘gross’ value added is solved following Goldar (1986) wherein he emphasised the latter on the ground of unreliable ‘depreciation’ figures reported in the published data. Thus, Gross Value Added at constant prices is used for the estimation of TFPG. The single deflation procedure (Appendix III specify the suitable deflators used) is used to obtain real gross value added. However, net value added is used, if otherwise stated.

(ii) **Input:** Two primary inputs (labour and capital) are used in the study. Since the choice of ‘Gross value added’ is made for the output which is derived by subtracting the value of input (comprises of total values of fuels, material consumed along with the other input costs involved (ASI)) from the total output; the use of three inputs viz, labour, capital and materials (including fuels etc.) would mean subtracting these inputs twice from the total output and would produce under-estimated results. So, to avoid this, only two primary inputs are used. The use of only two inputs is also evident in the study of Goldar (1986).

(iii) **Labour:** ‘Total persons engaged’ are used as a measure of labour input; which includes workers and persons other than workers which are equally important in getting the work done like supervisors, managers, technicians etc.

(iv) **Capital:** Gross fixed capital stock (at constant prices (1993-94)) is taken as the measure of capital input. The usual perpetual inventory method is used for the analysis which is derived as follows

**Perpetual Inventory Method**

Let \( B_t \) denotes the book-value of fixed assets at time \( t \). \( D_t \) is the depreciation made in the year and \( P_t \) the capital good price index (machine and machine tools in the present case) for the year \( t \), then the series on real fixed investment can be derived as

\[
I_t = \frac{(B_t - B_{t-1} + D_t)}{P_t}
\]
Further, two important estimates are required. One, the benchmark year estimate of gross fixed capital stock ($K_o$) at constant prices for the year 1980-81 is required. Second, choice needs to be made regarding the annual rate of discarding.

For the present estimate, $K_o$ was taken from the estimates of Balakrishnan and Pushpangadan (1994). For the choice of annual rate of discarding, we relied on the extended estimation done by Goldar (1986). Assuming the average life of fixed assets to be twenty years, he found that the appropriate rate of discarding for the manufacturing industries could be 2 percent. Thus, we have also taken 0.02 percent as the annual rate of discarding in the present study.

Then, the capital stock series ($K_t$) is derived after subtracting subsequently the annual rate of discarding assumes the following form which is as follows.

\[
K_t = K_{t-1} - 0.02 \cdot K_{t-1} + I_t
\]

\[
K_T = K_0 + \sum_{t=1}^{T} I_t
\]

(v) **R&D capital stock:** This is based on the R&D expenditure while using the perpetual inventory method as follows:

\[
S_t = (1-\delta) S_{t-1} + \text{R&D exp}_{t-1}
\]

Where $S_t$ is the R&D capital stock in period $t$;

$\delta$ is the rate of depreciation. This is assumed to be 5 percent as the average life of these industries is relatively less than the other fixed capital machinery due to the fast changing technologies. The R&D expenditure on nominal prices is converted into real R&D expenditure using the GDP deflator. The benchmark for the $S_t$ is calculated by doubling the base year R&D expenditure.

(vi) **Proportionate Net Value Added:** To capture the change in sectoral structure; ‘Proportionate Net Value added’ in industry $i$ at the time $t$ seems to be appropriate. It would reflect the changes in the various independent variables chosen for the structural transformation analysis (Section 3.4.4). By taking this variable it would take into account repeated observations on the same set of cross-section units (industries), which would attempt to simulate the whole range of transformation.
(vii) **Proportionate Fixed Capital (Investment explanation):** Accumulation of capital is regarded as the universal factor of growth (Sutcliffe, 1971). De Long and Summers (1991) found a strong association between the equipment investment and growth while citing the success stories of countries like UK, Japan etc. But the study by Temple and Voth (1998) found that the role of the equipment investment is important for the countries which are poor and are in the initial stage of industrialization, as it is an important constitute for building the base for the future growth. Thus, the inclusion of fixed capital in proportionate terms as the independent variable becomes inevitable. If the impact of this factor on the dependent variable came prominent, it would indicate that the level of industrialization in India is at its preliminary stage and there is lack of structural transformation away from the capital intensive low skill industries.

(viii) **Proportionate Employment (Employment absorption):** The ‘proportionate employment’ as the independent explanatory variable can be taken from two different angles. One, if the association of this variable is strong with the fixed capital and at the same time have an important impact in determining the dependent variable; it points to the fact that the industrial structure is dominated by the low skilled employment. Secondly, if the association of this variable is weak with the fixed capital but strong with the technology variable; it points to the fact that the inclusion of skilled manpower is high in the manufacturing industries describing structural transformation within the sector.

(ix) **Proportionate Exports (External Demand):** The share of exports in GDP is taken for explaining the structural shifts in the economy in the literature (notably, Chenery et al., 1986). But instead, the ‘proportionate value of exports’ is taken in the present analysis. If there is a high coefficient of exports as the explanatory variable, it would indicate the competitiveness (Lall, 2001) of the industrial sector. However, in the present globalization era, sustained competitiveness means the ability of nations to diversify industrial activities
from simple to advanced technologies (ibid, 2001). Thus, the high coefficient would indicate this diversification.

(x) **Proportionate Output (Domestic Demand):** The importance of domestic demand in determining the structural transformation and thus industrial growth is quite evident (Chenery et al., 1986, 1989). The ‘proportionate output’ in industry i is taken as the proxy for the domestic demand. If the coefficient of this variable is significantly higher, it probably shows that the industrial sector is driven by domestic demand instead of the external demand which could signify that the indigenous manufacturing industries are catering more towards the domestic demand. It could also signify that the sector is relatively in-competitive in the international market. But in case of a populated country, the relatively high demand could signify several things in an open economy. One, on a positive note, it could signify that the industries are competing its foreign counterparts in gaining the huge market. On the other hand, there is a possibility that the demand towards these industries could be due to certain indigenous preferences, certain biases or due to lower prices (which again could be due to either high rate of efficiency on the positive side or it could be also due to the poor quality products on the other end).

(xi) **Proportionate R&D expenditure (Technological Explanations):** The proportionate expenditure on research and development (R&D) is taken as the proxy for the technological up-gradation. The high coefficient of this variable would point to the fact that increased investment in R&D would acts as the means of achieving the high growth rate and the structural transformation (Lall, 2001). The study basically draws on the work by Temple and Voth (1998) wherein they have taken human capital as the driving force for industrialization and structural transformation within the sector. In this regard, Mani (2009) found that “the higher education sector in India is not a source of technology for the industry. However, the sector is an important source of human resource for the other actors in India’s national system of innovation”. Thus, in the present study, research and technology (R&D) investment for each industry is taken which seems to be more appropriate for analyzing the
sectoral growth. The stylized fact thus is that the industries towards the higher technology ladder are relatively sophisticated and requires higher R&D which is produced at the latter stage of industrialization.

(xii) **International import weighted knowledge spillover (FS):** The international trade weighted knowledge stock for industry i from j industry was calculated as follows:

$$FS_i = m_iR_j$$

where m denotes the share of imports from manufacturing industries of OECD countries. The industry wise imports statistics are used to estimate the value of m. This measure of knowledge stock is also described as pure rent spillover as the price paid during the imports does not reflect the full price of the product. Further, R is the knowledge stock approximated by R&D capital stock (3.6 (v)).

**3.6 CONCLUSION AND LIMITATION OF THE STUDY**

The present chapter to begin with, presents the rationale for the basic methodology undertaken in the study. Further, the chapter presents the various techniques used for the analysis. As per the various techniques are considered, various econometric models (cusum square method, semi-logarithmic model, single-kinked method, panel regression models for structural transformation and spillover effect analysis) and neo-classical methods (TFPG, both translog and SFA) of analysis are used for the estimations. In the chapter the rationale and construction of various variables used in the study are also presented.

The two basic limitations of the study are - First, the study is based on neo-classical methods of estimations, which are based on unrealistic assumptions of competitive equilibrium and constant returns to scale. Second, the construction of capital stock has always been in the centre of controversy, so does in the present study.

Third, apart from two sources of technological acquisition- indigenous R&D expenditure and technology spillovers from imports as taken into preview in the present study, there are various other factors like spillover through exports, FDI etc, which is not taken in to account due the limited scope of the study.