Chapter III

Description of Data and Preparation of Variables
3.1 Introduction:
This study considers both industry and firm level data to analyse the change in the performance indicators of firms and industries in pre and post deregulatory period. It picks up three industries: cement, pharmaceuticals and sugar. The basic source for industry level data is Annual Survey of Industries (ASI). The three digit level data of these industries have been taken into consideration. Apart from this, publications from several industry associations have also been consulted. In this context, information available from Cement Manufacturers' Association, Indian Sugar Mills' Association, National Federation of Co-operative Sugar Factories, Organisation of Pharmaceutical Producers of India and Indian Drug Manufacturers' Association are worth mentioning. Moreover, publications of the Centre for Monitoring Indian Economy have also been proved useful.

For firm level data, this study depends on the balance sheet and profit-loss account data of various firms available from Bombay Stock Exchange Official Directory. For cement industry 28 firms have been considered whereas for pharmaceuticals and sugar industry 32 and 27 firms have been chosen respectively. Time period considered for cement and pharmaceutical industry is form 1979-80 to 1995-96. On the other hand for sugar industry, it is 1975-76 to 1996-97. It should be mentioned that the length of the time series data for all firms in a particular industry is not homogeneous. Actually, due to unavailability of data for some firms, either there exists gaps in the time series or the time series is shorter in length. As a result of this, unbalanced panel data have been used for estimation. As balance sheets of different firms are published at different point of time, they have been adjusted to annual average to bring the homogeneity in the data set. Moreover, in some cases continuity of data is needed to run regression with lagged data. In those case gaps have been filled up with the method of interpolation. However, the numbers of cases of this type of adjustments are very few.

Many of the variables required for this study are readily available from balance sheet and profit & loss account. Some of the variables that are very important to analyse performance indicators have been created with the help of raw data. The next few
sections describe the creation of these variables, which have been used extensively in the following chapters. These variables are output, labour, material and capital stocks of firms. Standard methods have been applied to measure output, labour and material. A large section of this chapter has been devoted on the measurement of capital stock. Here, an attempt has been made to develop an alternative method to estimate firm level capital stock. The methodological improvement has been done with the help of a simple model. Average annual growth rate of output, capital, labour and material has also been reported in this chapter. In this context it should be mentioned that first annual growth rate of each firm has been calculated for each period. After that industry average growth rate for each period is calculated considering cross section average of growth rates. Industry average growth rates finally have been compared considering pre and post reform period.

3.2 Output:

The data of Net Sales reported in the balance sheet of each firm is considered to be output variable in current prices. For constant prices data, net sales have been transformed using the Index Numbers of Wholesale Prices\(^1\) of the corresponding products. To get the output data, it could have been a better option to add the net increase of finished good inventory with net sales. But Bombay Stock Exchange Official Directory does not report detail balance sheet of companies. It reports only changes in stocks which includes changes in inventory of raw materials, semi-finished and finished goods. Hence, a separate heading of finished good inventory is not available and because of this reason, only net sales value is considered as output.

Table 3.1: Average of Annual Growth Rates of Output in Selected Industries

<table>
<thead>
<tr>
<th>Average in Years</th>
<th>Cement</th>
<th>Pharmaceutical</th>
<th>Average in Years</th>
<th>Sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980/81-1995/96</td>
<td>0.19</td>
<td>0.12</td>
<td>1976/77-1995/96</td>
<td>0.12</td>
</tr>
<tr>
<td>1980/81-1990/91</td>
<td>0.20</td>
<td>0.14</td>
<td>1976/77-1990/91</td>
<td>0.11</td>
</tr>
<tr>
<td>1991/92-1995/96</td>
<td>0.17</td>
<td>0.08</td>
<td>1991/92-1995/96</td>
<td>0.13</td>
</tr>
</tbody>
</table>

Table 3.1 describes the average annual growth rates of output. It is observed that only in case of sugar industry, output growth rate has increased after 1991. In case of

\(^1\) Published by CSO, Government of India
pharmaceutical industry, it is reduced sharply. The main reason behind it is the higher rate growth of output prices during this time. The deregulation in the form of DPCO did not bring much enthusiasm among the producers in the industry. Cement industry also shows a declining output growth in post 1991 period. The output growth of cement industry was high immediately after partial deregulation when capacity increased substantially. In 1991, the growth rate has slowed down which may be because of lack of demand.

3.3 Labour:

Profit and loss account of a firm reports wages and salaries. It is a difficult task to derive labour input from this. There is no systematic way to calculate the number of employees in a company from the existing information. In this study, average wage rate have been calculated from the 3 digit ASI data. In this context, data under the heading ‘total employed’ and ‘total emoluments’ have been taken into consideration. The series of average wage rate have been used to extrapolate some of the recent data. Dividing wages and salaries by this average wage rate, we have got an approximate value of labour input. Due to unavailability of required information, inter firm as well as intra firm differences in the wage rate could not be implemented.

Table 3.2: Average of Annual Growth Rates of Labour in Selected Industries

<table>
<thead>
<tr>
<th>Average in Years</th>
<th>Cement</th>
<th>Pharmaceutical</th>
<th>Average in Years</th>
<th>Sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980/81-1995/96</td>
<td>0.13</td>
<td>0.06</td>
<td>1976/77-1995/96</td>
<td>0.02</td>
</tr>
<tr>
<td>1980/81-1990/91</td>
<td>0.14</td>
<td>0.06</td>
<td>1976/77-1990/91</td>
<td>0.01</td>
</tr>
<tr>
<td>1991/92-1995/96</td>
<td>0.12</td>
<td>0.07</td>
<td>1991/92-1995/96</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Labour growth rate has reduced for cement industry and increased for sugar and slightly for pharmaceutical industry in post 1991 period. Average labour growth rate is quite low for sugar industry while it is significantly high in case of cement industry. So, we can conclude, after 1991, employment growth rate did not increase significantly in the selected industries.

3.4 Material:

Material input is calculated from the data ‘stock consumed’ reported in profit and loss account. Stock consumed is defined as (opening stock + purchase of stock- closing
stock. The word ‘stock’ consists of raw materials and purchased semi-finished and finished goods. While calculating the value of stock consumed, firms use the cost of raw materials and indirect manufacturing cost of the produced goods. So, in an approximate sense, it reveals the material cost of the stock consumed. The flow figures under ‘stock consumed’ are reported in current prices. We do not have any ready made price index, which can be used for transforming this data into constant prices. This is because of the fact that material consists of many things and they vary from industry to industry. For convenience, a separate price index have been prepared for each industry considering the weight distribution of materials in each industry available from ‘input-output tables’ of 1983-84 (Published by CSO, Dept. of Statistics, 1990) and their corresponding wholesale price index. This new price index has its base as 1981-82.

Table 3.3: Average of Annual Growth Rates of Material in Selected Industries

<table>
<thead>
<tr>
<th>Average in Years</th>
<th>Cement</th>
<th>Pharmaceutical</th>
<th>Average in Years</th>
<th>Sugar</th>
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<td>0.13</td>
</tr>
<tr>
<td>1991/92-1995/96</td>
<td>0.10</td>
<td>0.07</td>
<td>1991/92-1995/96</td>
<td>0.17</td>
</tr>
</tbody>
</table>

Table 3.3 shows the material growth rate for the selected industries. It shows a declining trend for cement and pharmaceutical industry while has increased for sugar industry in the post 1991 period. Material growth dropped sharply for pharmaceutical industry. Reduction in material growth rate in cement and pharmaceutical industry is possibly related to fall in output growth in these industries.

3.5 Capital Stock:

The most common method of measuring capital stock is Perpetual Inventory Accumulation Method (PIAM). Mathematically it can be written as, \( K_t = (1-\delta)K_{t-1} + I_t \), where \( K_t \) is the actual capital stock in the \( t \)-th period, \( I_t \) is the real investment in the \( t \)-th period and \( \delta \) is the depreciation rate. As the database of capital stock is always available in the value terms, we find difficulties to transform it into constant prices. Actually the major part of the literature is about the various methods of price correction. The book

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2 This section is heavily dependant on Nag(1998)
value of capital indicates the value of capital at the historical cost, which implies that capital stock consists of several vintages. So, we can not transform the book value into constant prices just dividing it by price index. The problem remains even at the base year or the benchmark year. The literature suggests several type of replacement cost applicable on the book value of the benchmark year. Once the capital stock of the base year is available, then PIAM can be applicable smoothly.

In India the studies on this area was initiated long back. The older studies like Gujarati (1967), Narasimhan and Fabrycy (1974) and few others used book value of capital stock, net of cumulative depreciation as capital stock. This method was done with price correction in other studies. Reddy and Rao (1962), Raj Krishna and Mehta (1968) and Mehta (1974, 1976) considered the deflated book value as the capital stock. Other studies such as Dutta-Majumdar (1967) and Sankar (1970) used perpetual inventory accumulation method. But they concentrated on the book value of capital stock rather than replacement value. All these studies ignore the very important point that book value of capital is measured at the historical cost and hence should not be used directly or indirectly, dividing by deflators as capital stock.


Banerji used the double of book value for 1946 as capital stock. Both Banerji and Roychoudhury used depreciation series at book value. Since depreciation at book value is known as a gross overestimation, these studies suffer from serious bias. Hashim and Dadi proceeded with perpetual inventory method. In order to estimate the replacement value of the capital stock they used the age composition of various assets. Goldar used PIAM considering the age structure and mortality pattern of the fixed assets as assumed by Hashim and Dadi. To arrive at the dates of purchase of various fixed assets he referred to the Report of the Taxation Enquiry Commission, 1953-54. He considered gross fixed capital stock (GFCS) at constant prices as capital input. Ahluwalia (1991) preferred to use GFCS at constant prices using the Annual Survey of Industries (ASI) data. She also
calculated from ASI the gross investment at constant prices. For benchmark year estimation she relied on study by Hashim and Dadi.

ICICI (1994) considered a disaggregated company level study. This becomes more challenging, as there is no good benchmark year capital stock estimation available at company level. ICICI provided a new method for firm level capital stock calculation. It used the information of net capital stock (NCS) available from National Accounts Statistics (NAS) and found out the ratio of book value to replacement value for some years (for example, 1974-75, 1978-79, 1984-84, 1988-89). These ratios have been kept constant for sub-periods (1974-78), (1978-84), (1984-88), (1988-91). Then in each sub-period these ratios are used to calculate replacement values.

Srivastava (1996) has proceeded with further details. He found out the revaluation factors for gross and net capital stock separately and defined the replacement cost of capital as "Revaluation factor multiplied by Value of capital stock at historic cost". For deriving the revaluation factor Srivastava assumed fixed investment growth rate and inflation rate. Due to lack of better alternative he assumed that no firm is using vintages earlier than 1965. For firms incorporated before 1965, the growth rate of investment is assumed to be equal to the growth rate of gross fixed capital formation at 1980-81 prices and is same for all firms. For firms established after 1965 he assumed different growth rates. For calculating revaluation factor of net fixed capital stocks (NFCS), he considered both economic and financial depreciation rates. The economic depreciation rate is assumed to be 7.1 per cent and financial depreciation rate varies from firm to firm and calculated from the data.

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3 Srivastava derived the revaluation factor for net fixed assets in the following way:

Net Fixed Asset (at historical cost) = \( P_t I_t (1-d) + P_{t-1} I_{t-1} (1-d)^2 + \ldots + P_1 I_1 (1-d)^t \)

and Net Fixed asset (at replacement cost) = \( P_t I_t (1-\delta) + P_{t-1} I_{t-1} (1-\delta)^2 + \ldots + P_1 I_1 (1-\delta)^t \)

where \( P_t \) and \( I_t \) are the price of fixed asset and investment at the t th period respectively. \( D \) and \( \delta \) are accounting and economic depreciation rates. The revaluation factor for Net Fixed Asset is derived as

\[
R^h = \frac{\text{Nfa}^h}{\text{Nfa}^t} = \frac{[(1+g)^{t+1} - (1-\delta)^{t+1}] [(1+\pi)(1+\pi)(1-d)]}{(1+\delta) [(1+g)(1+\pi)]^{t+1} - (1-\delta)^{t+1}}
\]

where \( g \) and \( \pi \) are the growth rates of investment and prices and defined as \( g = \frac{I_t}{I_{t-1}} - 1 \) and \( \pi = \frac{P_t}{P_{t-1}} - 1 \). Here, both accounting and economic depreciation rates are treated geometrically.
This section offers an alternative method to estimate net capital stock of a firm. This alternative method of estimation of replacement value considers the age structure of a firm, different growth rates of all firms and fixed inflation rate. The model finds out the initial investment \((I_0)\), and constant growth rate \((g)\) of capital stock from the data of gross fixed capital or gross block (GB hereafter) and accumulated depreciation (AD hereafter) which are available from balance sheets of companies. It also considers both economic and financial depreciation rates.

3.5.1 Assumptions of the Model:

- Let us suppose one firm was incorporated in year ‘0’. We do not have data from ‘0’ to \(t_1\)th period. The data of GB and AD are available from \(t_1\) to \(t_2\) period. We would like to have the replacement value of capital at \(t_1\)th period. So we assume a positive constant growth rate of gross fixed capital stock between period ‘0’ to \(t_1\) as ‘g’ which is unknown in the model. Investment in any period is assumed to be a function of the existing gross capital stock, which can be expressed through this growth rate. In the literature growth rate of gross fixed capital have been used to express the volume of investment. For example, Srivastava (1996) used constant growth rate of gross fixed capital formation (GFCF) for Indian firms, which were incorporated before 1965 as a proxy of investment growth rate.

- The initial investment at 0-th period is also unknown and is assumed to be \(I_0\).

- The long run inflation rate of gross fixed capital formation in the economy is ‘i’.

- It has been observed that financial depreciation is used for tax saving purpose. As a consequence of this, company has a tendency to depreciate the financial value of a machine at a rate near to the permitted rate by the company law. On the other hand the machine remains in a running condition even after its financial value gets depreciated. Actually, the economic value of any machine gets depreciated geometrically while its financial value follows a straight-line depreciation rate for tax saving purpose. Let us assume that the straight-line depreciation rate is \((1/\Theta)\). This is considered as financial depreciation rate, which implies that a machine will be obsolete after ‘\(\Theta\)’ years. This is
being used to calculate AD at current prices, data of which is available from the balance sheet. The economic depreciation rate is assumed to be \( \delta \).

The objective of the model is to find out the replacement value of capital at \( t \)th period \( (k_{t1}) \) from the book value using the equations of GB & AD. Actually, the model concentrates on the specification of the equations of GB & AD. After that it becomes a model of two equations (for GB & AD) with two unknowns \( (g \& I_0) \). Solving them and using 'perpetual inventory method' \( K_{t1} \) will be derived with \( \delta \) as the economic depreciation rate.

3.5.2 The Model:

Let \( g \) be the growth rate of gross fixed capital at constant prices and \( I_t \) be the investment in \( t \) th period. Investment at the \( 0^{th} \) period is same as the gross or net capital stock at the \( 0^{th} \) period. Gross capital of other periods is defined as the sum of investment flow till that period and net capital is defined using PIAM and denoted as

\[
K_t = (1 - \delta) K_{t-1} + I_t.
\]

So investment in period 1 is defined as

\[
I_1 = g I_0, \quad g > 0.
\]

Similarly to the first period, investment in other periods is defined in the following way:

\[
I_2 = g (I_0 + I_1) = g (1 + g) I_0
\]

\[
I_3 = g (I_0 + I_1 + I_2) = g (1 + g)^2 I_0
\]

Similarly, \( I_t = g(1 + g)^{t-1} I_0 \)

The equation of GB at the \( t \)th period,

\[
GB = P_0 I_0 + P_1 I_1 + P_2 I_2 + \cdots + P_t I_t
\]

If \( P_t \) is the price of capital at \( \tau \)th period and \( 'i' \) is the inflation rate of \( P \), let, \( P_t = P_0 (1 + i)^t \)

So, using the expression of \( I_t \) and \( P_t \) we get,

\[
GB = P_0 I_0 \left\{ 1 + g \sum_{\tau=1}^{t} \frac{(1+i)^\tau (1+g)^\tau}{1+g} \right\}
\]

(1)
The equation AD has to be formulated using financial depreciation (1/θ). The equation of AD has two parts -- i) The machine which was installed before (t-θ) period from today and are not in use. For this machine the accumulated depreciation is the value of the machine itself. So, in this period GB = AD,  ii) The second phase starts from (t-θ+1) th period and ends at t th period. In this period, depreciation rules work properly.

The phase i) GB = AD from period 0 to (t-θ ) and the equation of AD is

\[ P_0 I_0 \left\{ 1 + \frac{g}{1+g} \sum_{t=1}^{t-θ} (1+i)^t (1+g)^t \right\} \]  \hspace{1cm} (2A)

The phase ii) from period (t-θ +1) to t th period .

Let us consider (t-θ +1) period as 1 and t th period as θ . The investment in the last period i.e in θth period has 0 depreciation and the earliest vintage (for the period (t-θ +1)) has only 1/θ portion left. So the depreciated amount is (θ-1)/ θ portion of the investment. With this logic we can calculate total accumulated depreciation of this phase.

The equation of AD in this phase is –

\[ \sum_{m=1}^{θ} \frac{θ - m}{θ} g (1+g)^{[1-(θ-m)-1]} I_0 P_0 (1+i)^{[t-(θ-m)]} \]

\[ = P_0 I_0 \frac{g}{1+g} (1+g)^{1-θ} (1+i)^{1-θ} (1/θ) \sum_{m=1}^{θ} (θ - m)(1+g)^m (1+i)^m \]  \hspace{1cm} (2B)

So, the complete equation of AD is (combining 2A and 2B ) :

\[ AD = P_0 I_0 \left\{ 1 + \frac{g/(1+g)}{1} \sum_{t=1}^{t-θ} (1+i)^t (1+g)^t \right\} + \left[ \frac{g/(1+g)}{1} (1+g)^{t-θ} (1+i)^{t-θ} (1/θ) \sum_{m=1}^{θ} (1+g)^m (1+i)^m (θ - m ) \right] \]  \hspace{1cm} (2)
Now, if we look at the equations (1) and (2) we find that they become two equations with two unknowns and easily solvable. Dividing (1) by (2) we get

\[
\frac{1 + g}{1+g} \sum_{\tau=1}^{t} (1+i)^\tau (1+g)^\tau = \frac{GB}{AD} = C
\]

Where \( C \) is the ratio of gross block to accumulated depreciation.

The above equation considers the case that \( t > \theta \). For which we find two parts of the equation (2) as (2A) and (2B). When \( t \leq \theta \), the equation of AD becomes

\[
AD = P_0 I_0 (t/\theta) + P_1 I_1 ((t-1)/\theta) + P_2 I_2 ((t-2)/\theta) + \cdots + P_{t-1} I_{t-1}(1/\theta) + P_t I_t 0
\]

Or, \( AD = P_0 I_0 (1/\theta) \left[ t + g \sum_{m=1}^{t} (1+i)^m (1+g)^m (t-m) \right] \)  

Consequently, The equation (3) for \( t \leq \theta \) becomes

\[
\frac{1 + g}{1+g} \sum_{\tau=1}^{t} (1+i)^\tau (1+g)^\tau = \frac{GB}{AD} = C \quad (5)
\]

The equation (3) or (5) has only one unknown variable i.e. \( g \). So it can be written as

\[
f(g) = C \quad (6)
\]

- **Proposition I**: Equation (3) has a unique positive solution, and equation (5) has the same if \( f(0) < C \).

**Proof**: Both the equations (3) and (5) can be written as \( f(g) = C \). They have unique positive solutions if they follow the steps described below.
Step I: \( f'(g) > 0 \) for \( g > 0 \)

The first order derivatives of both equation (3) and (5) are positive. For derivation, please see the Annexe II. So, these equations are monotonic in nature and increasing also.

Step II: \( f(g) \to \infty \) as \( g \to \infty \).

Let us divide both numerator and denominator of equation (3) and (5) by \((1+g)^{-1}\), then rearranging them and putting \( g = \infty \), we get a finite denominator and infinite numerator. This implies that overall equation \( f(g) \to \infty \). So, both the equations tend to infinity as \( g \) tends to infinity.

Step III: \( f(0) < C \).

For equation (3), putting \( g = 0 \), we get \( f(0) = 1 \), whereas \( C > 1 \) by definition (as \( GB > AD \)). So, \( f(0) \) is less than \( C \) for equation (3). For equation (5), \( f(0) = (\theta / t) \geq 1 \) as \( t \leq \theta \) and \( C \) remains greater than 1. So, there is a possibility that \( f(0) \) may be greater than \( C \). Let us now consider the economics of it. \( f(0) \) implies that \( GB \) is constant over time as capital stock growth rate is 0, but \( AD \) is allowed to increase with a linear financial rate of depreciation \((1/\theta)\). For \( t < \theta \), the numerator remains greater than the denominator, or in other words, gross block does not get fully depreciated. When, \( f(0) \) is greater than \( C \), then there is a possibility that the firm is using higher rate of depreciation compared to the formula rate \((1/\theta)\). So, if \( f(0) > C \), then we can reduce \( f(0) \) through a upward revision of the formula depreciation rate and make \( f(0) < C \). We can use this method as long as \((1/\theta)\) is less than the rate allowed by the corporate law. The maximum depreciation rate we can use is the rate permitted by the corporate law. If even after using this new depreciation rate \( f(0) \) still remains greater than \( C \) then either there is a problem in the data or \( g \) is negative. If the firm is depleting capital stock i.e. \( GB \) is decreasing then \( C \) may remain as less than \( f(0) \). In this case, the optimal \( g \) will be negative, which is because of negative investment and decreasing GB. But for a new firm (\( t \leq 0 \), is applicable mainly for new firm) the depleting capital stock is unlikely and a rare phenomena. If a new company is in distress then it is quite possible its policy on
depreciation and depletion of capital does not follow a particular rule which can be captured by a definite formula. On this ground we ignore this possibility in this model.

So, from the above discussion we can say that equation (3) follows all conditions including \( f(0) < C \) which imply that \( f(g) \) is monotonically increasing between 0 and \( \infty \) and it intersects \( C \) from the below and hence it has a unique positive solution, On the other hand equation (5) also follows same steps except in certain cases \( f(0) \) remains greater than 0. Other than this possibility equation (5) has also unique positive solution.

### 3.5.3 Solution of \( I_0 \):

Once we get the value of \( g \) from equation (3) or from (5), we can use it to solve \( I_0 \). Let us consider that \( g^* \) is the solution of \( f(g) = C \) and value of \( GB \) at the base year is \( 'a' \). Then from equation (1) we get

\[
GB = a = P_0 I_0 \{ 1 + \frac{g^*}{1+g^*} \sum_{t=1}^{\infty} \frac{(1+i)^t (1+g^*)^t}{1+g^*} \}
\]

\[
I_0^* = \left[ \frac{a \{ 1 - (1+i)(1+g^*) \}}{P^*(1+i)^s [1-(1+i)(1+g^*)+ g^*(1+i)(1-(1+i)^t)(1+g^*)]} \right]
\]

where \( P^* \) is the base year price index of the fixed capital, \( s \) is the difference of years between period 0 and base year and \( I_0^* \) is the initial investment derived from the model.

### 3.5.4 Calculation of Replacement Value of Net Capital Stock:

The net capital stock at \( 't' \) is \( K_t \) which can be calculated once we get the value of \( I_0 \) and \( g \). At the period 0, the initial investment \( I_0 \) is equal to that year's capital stock i.e., \( K_0 \)

So, \( K_0 = I_0 \)

\[
K_1 = (1-\delta)K_0 + I_1, \quad \delta \text{ is the economic depreciation rate}
\]

\[
= (1-\delta)K_0 + g I_0
\]

\[
K_2 = (1-\delta)K_1 + I_2
\]

\[
= (1-\delta)[(1-\delta)I_0 + g I_0] + g(1+g)I_0
\]
\[K_3 = (1-\delta)K_2 + I_3\]
\[= (1-\delta)[(1-\delta)^2 I_0 + g(1-\delta)I_0 + g(1+g)I_0] + g(1+g)^2 I_0\]
\[= (1-\delta)^3 I_0 + g(1-\delta)^2 I_0 + g(1-\delta)(1+g)I_0 + g(1+g)^2 I_0\]

Similarly,
\[K_t = (1-\delta)K_{t-1} + I_t\]
\[= (1-\delta)^t I_0 + g I_0 [(1-\delta)^{t-1} + (1+g)(1-\delta)^{t-2} + (1+g)^2 (1-\delta)^{t-3} + \ldots + (1+g)^{t-2} (1-\delta) + (1+g)^{t-1}]\]
\[= (1-\delta)^t I_0 + g I_0 \sum_{i=0}^{t-1} (1+g)^i (1-\delta)^{t-(t+i)}\]

So, finally the replacement value of capital stock at t th period with g* as real investment growth rate and I_0* as initial investment is
\[K_t = (1-\delta)^t I_0* + g* I_0* \frac{(1-\delta)^{t-1} - (1+g*)^{t-1}}{(1-\delta) - (1+g*)}\]

3.5.5 Modification:
In the above sections, the positive growth rate of real investment between period 0 to t1 has been calculated. Upto this, the only data point i.e., the ratio of GB to AD at the t1 th period is used. To make the model more rigorous the following approach is applied.

Let us consider:

a) \(g_1\) as the real investment growth rate between period 0 to t1.
b) \(g_2\) as the real investment growth rate between period 0 to t2.
c) \(g_3\) as the real investment growth rate between period t1 to t2.
d) \(g'\) as the investment growth rate between period 0 to t1, calculated using \(g_2\) and \(g_3\).
e) “Mean \(g_1\)” as average of \(g_1\) and \(g'\).

For more clear understanding the following diagram may be helpful.
Theoretically, \( g'_{1} \) and \( g_{1} \) should give us the same value and hence the formula should be,

\[
(1 + g_{2})^{t_{2}} = (1 + g_{3})^{(t_{2}-t_{1})} (1 + g'_{1})^{t_{1}}
\]

\[
\therefore g'_{1} = \frac{t_{1}}{t_{2}} \sqrt{\frac{(1 + g_{2})^{t_{2}} / (1 + g_{3})^{(t_{2}-t_{1})}}{(1 + g'_{1})^{t_{1}}}} - 1
\]  \hspace{1cm} (9)

But due to \( g_{3} \), which captures the fluctuating investments between period \( t_{1} \) to \( t_{2} \), \( g'_{1} \) may be different from \( g_{1} \). In this case we take the average of \( g'_{1} \) and \( g_{1} \) as

\[
\text{Mean } g_{1} = \frac{(g'_{1} + g_{1})}{2}
\]

3.5.6 Empirical Application:

This model has been applied to derive the capital stock of the sample firms. Here, exogenous factors are \( i \), \( \theta \) and \( \delta \). If we assume the proper values of these factors, we can derive the capital stock of several firms. The information of GB, AD and age of the companies have been taken from the various issues of Official Directory of Bombay Stock Exchange. The implicit deflator of registered manufacturing sector of India with 1981-82 as base is considered as price index of fixed capital. The long run inflation for gross fixed capital formation is calculated as 8.1 percent. From data it has been observed that average \( \theta \) for all firms is equal to 7 years. It could have been a better option if different \( \theta \)s were calculated for different firms. But to reduce calculation average \( \theta \) has been taken. Economic depreciation is assumed to be 10 per cent. In the literature we find that there is a wide variation considering the economic depreciation rate in India. Raut (1995) has taken it as 15 percent while in Srivastava (1996) it is 7.1 percent. According to, Hulten and Wykoff (1981) the manufacturing machineries have higher depreciation rate which varies from 10 per cent to 27 per cent and buildings have a lower rate varying
between 3 to 5 per cent. So, depreciation rate should be calculated using the weights of buildings and machineries in that company. Moreover, economic depreciation for the country as a whole is well below 10 percent. In Raychaudhuri (1996) it is 6.7 percent for NAS data. But for individual companies it is expected to be higher than that. So, 10 percent rate can be used particularly when it lies between Raut’s, Srivastava’s and Raychaudhuri’s rate.

Moreover, a simple partial productivity analysis shows that the capital stock measured here have higher explanatory power as compared to the other measure like net block. Firms are clubed together according to their respective industries viz. cement, pharmaceuticals and sugar. Then partial productivities have been calculated both at current and constant price. The regression results have been shown in the table below.

Table 3.4: Regression Results of Partial Productivity Analysis

<table>
<thead>
<tr>
<th>Dep. Var</th>
<th>CEMENT</th>
<th>PHARMACEUTICAL</th>
<th>SUGAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indep. Var</td>
<td>(Current Pr)</td>
<td>(Const.Pr.)</td>
<td>(Current Pr)</td>
</tr>
<tr>
<td>C1</td>
<td>ΔNS,</td>
<td>.048</td>
<td>.057</td>
</tr>
<tr>
<td>ΔK,</td>
<td>.787</td>
<td>.724</td>
<td>.55</td>
</tr>
<tr>
<td>ΔNBCST,</td>
<td>.608</td>
<td>.535</td>
<td>.475</td>
</tr>
<tr>
<td>C2</td>
<td>.045</td>
<td>.058</td>
<td>.005</td>
</tr>
<tr>
<td>ΔKCNT,</td>
<td>.892</td>
<td>.810</td>
<td>.690</td>
</tr>
<tr>
<td>ΔNB,</td>
<td>.745</td>
<td>.696</td>
<td>.597</td>
</tr>
<tr>
<td>R²</td>
<td>.53</td>
<td>.47</td>
<td>.30</td>
</tr>
</tbody>
</table>

ΔNS, = Log (NS) - Log(NS,), NS = Net Sales.  ΔY, = Log (Y) - Log(Y,1), Y = Output
ΔK, = Log (K) - Log(K,1), K = Capital at constant price(measured from the model),
ΔKCNT, = Log (KCNT) - Log(KCNT,1), KCNT = K* Deflator
ΔNB, = Log (NB) - Log(NB,1), NB = Net Block, ΔNBCST, = Log (NBCST) - Log(NBCST,1), NBCST = NB/Deflator

In all these cases, the regressions with measured capital stock show higher R² as compared to the regressions with net block. So, measured capital stock has more explanatory power to analyse partial productivity.
Table 3.5: Average of Annual Growth Rates of Capital in Selected Industries

<table>
<thead>
<tr>
<th>Average in Years</th>
<th>Cement</th>
<th>Pharmaceutical</th>
<th>Average in Years</th>
<th>Sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980/81-1995/96</td>
<td>0.09</td>
<td>0.11</td>
<td>1976/77-1995/96</td>
<td>0.09</td>
</tr>
<tr>
<td>1980/81-1990/91</td>
<td>0.10</td>
<td>0.11</td>
<td>1976/77-1990/91</td>
<td>0.06</td>
</tr>
<tr>
<td>1991/92-1995/96</td>
<td>0.07</td>
<td>0.10</td>
<td>1991/92-1995/96</td>
<td>0.17</td>
</tr>
</tbody>
</table>

Table 3.5 shows average growth rates of capital in selected industries. On an average capital growth rate for cement industry has come down after 1991. Capital growth rate was high just after the partial deregulation in 1982. It encouraged higher investment and capacity generation in case of cement industry. Growth rate remains more or less stagnant in case of pharmaceutical industry with a slight drop in post 1991 period. It increased significantly for sugar firms after 1991.

3.6 Conclusion:

In this chapter a discussion has been made on the data sources and preparation of some important variables which will be used in the following chapters. A big section has been devoted to give an alternative estimation technique to measure firm level capital stock. Apart from this, methods for calculating output, labour and material have also been discussed. These variables will be used to estimate production functions of the selected industries. Moreover, for productivity and efficiency analysis and for calculation of capacity utilisation these variables are required.