Chapter 3
Research Methodology

The methodology adopted in the present study is covers three major aspects:

3.1. Total Factor Productivity Growth
3.2. Causality Test between TFPG and REER
3.3. Multi-variate Regression Analysis between TFPG and Independent Variables
3.4. Basic Panel Regression Analysis

3.1. Total Factor Productivity Growth

3.1.1. Calculation of Total Factor Productivity Growth at the Industry Level

Productivity can be measured with respect to a single input or a combination of inputs. The partial or single factor productivity (SFP) is defined as the ratio of the volume of output to the quantity of the factor of production for which productivity is to be estimated. The concept of multi factor productivity (MFP) tries to circumvent the problem encountered in interpretation of SFP estimates in the event of changing factor intensities. MFP is defined as the ratio of real output to a weighted sum of the inputs used in the production process. MFP is deemed to be the broadest measure of productivity and efficiency in resource use. 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 factors of production, learning by doing, *etc*.

The TFP growth can be calculated in number of ways. To estimates productivity growth of Indian manufacturing have continuously raised questions in terms of the methodology used. There are various methodological issues relating to interpreting TFP growth rates: (1) growth accounting versus econometric estimation, (2) value added versus gross output, (3) measuring intermediate inputs, and (4) aggregate procedure. However, the two most common approaches used in case of Indian manufacturing are “Econometric Estimation Approach” and “Growth Accounting Approach”. Under the Growth accounting approach, the TFP growth estimated by subtracting the weighted input growth from the output growth. In estimation of TFP growth with econometrics approach, there are many problems such as multi-colinearity, autocorrelation and the need for large sample associated with the econometric estimation procedure may often pose serious challenge to the correct estimate of the parameters of production function (Trivedi, 2000).

Productivity can be measured using either parametric or non-parametric methods. In table 3.1, is the outline of the main methodologies used in the literature to measure productivity. This study used Translog production function method to calculate productivity.

Table 3.1: Measure Productivity and Efficiency Levels: Methodologies Used in the Literature

Estimation Method Main Options Measure	**Estimation Method Main Options Measure**	**Estimation Method Main Options Measure**	**Estimation Method Main Options Measure**
Parametric Estimation	Production Function	Cobb-Douglas, Translog, Constant Elasticity of Substitution (CES)	Productivity Growth (Descriptive)
	Stochastic Frontier	Cobb-Douglas, Translog, with alternative assumptions about the distribution of random variable (Ui) that capture inefficiency	Efficiency level (Normative)
Non-Parametric Estimation	Index of Productivity	Discrete approximations, based on the various functional forms of production functions, such as, Cobb-Douglas, Translog, etc.	Productivity Change (Descriptive)
		Malmquist index based on distance functions	Productivity and efficiency change (Descriptive and Normative)
	Data Envelopment Analysis	Input or Output orientations, Constant/ Non-constant/Variable Returns to Scale	Efficiency level (Normative)

Source: Trivedi et al. 2011

It is important to differentiate between technical progress and total factor productivity increase. The former may be defined as the advances in knowledge with respect to the state of the art of production of an output using factor inputs. The increase in total factor productivity, however, is a broader concept encompassing the effect not only of technical progress but also of better utilization of capacities, learning-by-doing and improved skills of labour, etc. Total factor productivity growth is a composite measure of technological change and changes in the efficiency with which known technology is applied to production (Alhuwalia, 1991).

In order to avoid these problems, the present study makes use of growth accounting approach for estimation of productivity growth. The Translog Index of Total Factor Productivity (TFP) is a discrete approximation to the Divisia Index of Technical Change. Translog Index Number is symmetric in data of different time periods and also satisfies the factor reversal test approximately. The Translog production function of TFP has been used for the TFP estimates presented in the study, as done earlier by Alhuwalia (1991), Rao (1996), Pradhan and Barik (1998) Das (2003), Goldar and Kumari (2003), Goldar (2004), Das and Kalita (2009) Das et.al. (2010) and Virmani & Hashim (2011). The Translog production function of TFP has been used for the measurement of TFP and the methodology assume perfect competition and constant returns to scale, further, the revenue share of the factor inputs sum to unity. This study concentrates on individual industry productivity rather than aggregate productivity. Consider an aggregate production function with four factor of production.

$$Y = F(L, K, R, E, T) \qquad \text{Equation (1)}$$

Where, 'Y' denotes aggregate output, 'L' denotes labour input 'K' denotes capital input, 'M' denote consumption of raw material, 'E' denote energy input and 'T' denote time. It is assumed that 'F' characterized by constant return to scale. These aggregates are taken as function of their components.

$$Y = Y(Y_1, Y_2 \ldots\ldots\ldots Y_m) \qquad \text{Equation (2)}$$

$$K = K(K_1, K_2 \ldots\ldots\ldots K_n) \qquad \text{Equation (3)}$$

$$L = L(L_1, L_2 \ldots\ldots\ldots L_q) \qquad \text{Equation (4)}$$

$$M = M(M_1, M_2 \ldots\ldots\ldots M_s) \qquad \text{Equation (5)}$$

$$E = E(E_1, E_2 \ldots\ldots\ldots E_u) \qquad \text{Equation (6)}$$

Similarly assumption about continuity, differentiability and homogeneous are made for these functions.

$p_{1}, p_{2}, \ldots\ldots p_{m}; r_{1}, r_{2} \ldots\ldots r_{n}; w_{1}, w_{2} \ldots\ldots w_{q}; g_{1}, g_{2} \ldots\ldots g_{s}; c_{1}, c_{2} \ldots\ldots c_{x}$

Corresponding aggregation prices are denoted by 'p', 'r', 'w', 'g' and 'c'. Under the assumption of perfect competition and profit maximization, the condition of producer's equilibrium require that the share of the factors be equal to their elasticities, so that

$$V_K = \frac{rK}{pY} = \frac{d\log Y}{d\log K} \qquad \text{Equation (7)}$$

$$V_L = \frac{wL}{pY} = \frac{d\log Y}{d\log L} \qquad \text{Equation (8)}$$

$$V_M = \frac{gM}{pY} = \frac{d\log Y}{d\log M} \qquad \text{Equation (9)}$$

$$V_M = \frac{cE}{pY} = \frac{d\log Y}{d\log E} \qquad \text{Equation (10)}$$

Because of constant return $V_K + V_L + V_M + V_E = 1$. Similarly, for individual components the conditions of production of producer's equilibrium require

$$SY_i = \frac{p_i Y_i}{pY} = \frac{d\log Y}{d\log Y_i} \qquad i = 1,2,\ldots\ldots m \qquad \text{Equation (11)}$$

$$SK_j = \frac{r_j K_j}{rK} = \frac{d\log K}{d\log K_j} \qquad j = 1,2,\ldots\ldots n \qquad \text{Equation (12)}$$

$$SL_u = \frac{w_u L_u}{wL} = \frac{d\log L}{d\log L_u} \qquad u = 1,2,\ldots\ldots q \qquad \text{Equation (13)}$$

$$SM_o = \frac{g_o M_o}{gM} = \frac{d\log M}{d\log M_o} \qquad o = 1,2,\ldots\ldots s \qquad \text{Equation (14)}$$

$$SE_z = \frac{c_z E_z}{cE} = \frac{d\log E}{d\log E_z} \qquad z = 1,2,\ldots\ldots x \qquad \text{Equation (15)}$$

'SY_i' is the share of the i^{th} output component in aggregate output. Similarly, 'SK_j', 'SL_u', 'SM_o' and 'SE_z' is the share of the j^{th} capital, u^{th} labour, o^{th} material and z^{th} energy input aggregate capital, labour, material and energy respectively. Linear homogeneity required.

$$\textstyle\sum_i SY_i = \sum_j SK_j = \sum_u SL_u = \sum_o SM_o = \sum_z SE_z = 1$$

Differentiating equation (1) totally with respect to that and rearranging terms, it obtain

$$\frac{d \log Y}{dT} = \left[V_K \left(\frac{d \log K}{dT}\right) + V_L \left(\frac{d \log L}{dT}\right) + V_M \left(\frac{d \log M}{dT}\right) + V_E \left(\frac{d \log E}{dT}\right) + V_T \right] \quad \text{Equation (16)}$$

This expression 'V_T' is called the Divisia quantity index of technological change. It should be noted that the above expression

$$\frac{d \log Y}{dT} = \sum_i SY_i \frac{d \log Y_i}{dT} \quad \text{Equation (17)}$$

$$\frac{d \log K}{dT} = \sum_j SK_j \frac{d \log K_j}{dT} \quad \text{Equation (18)}$$

$$\frac{d \log L}{dT} = \sum_u SL_u \frac{d \log L_u}{dT} \quad \text{Equation (19)}$$

$$\frac{d \log M}{dT} = \sum_o SY_o \frac{d \log M_o}{dT} \quad \text{Equation (20)}$$

$$\frac{d \log E}{dT} = \sum_z SE_z \frac{d \log E_z}{dT} \quad \text{Equation (21)}$$

Thus the weight average of growth rates of individual components gives the growth rate for the aggregate. To the price side, it is seen that the assumption of constant returns to scale, perfect competition and profit maximization require that the prices of output, capital, labour, material and energy be consistent with the following equation.

$$pY = rK + wL + gM + cE \quad \text{Equation (22)}$$

Given this equitation one can express the 'p' as a function of 'r', 'w', 'g', 'c' and 'T'

$$p = p\ (r, w, g, c, T) \quad \text{Equation (23)}$$

This referred to as the price function. From the point of view of the price function, technological change is define as

$$V_T = - \frac{d \log p}{dT} \quad \text{Equation (24)}$$

Also, it is possible to write

$$\frac{d \log p}{d\mathrm{T}} = \mathrm{V_K}\left(\frac{d \log r}{dT}\right) - \mathrm{V_L}\left(\frac{d \log w}{dT}\right) - \mathrm{V_M}\left(\frac{d \log g}{dT}\right) - \mathrm{V_E}\left(\frac{d \log c}{dT}\right) - V_T \quad \text{Equation (25)}$$

This from give us the Divisia price index of technological change. Definitions of other terms in equations (25) are similar to those given in equations (7) to (10) and (17) to (21).

For application of data at discrete point of time approximation to the continuous Divisia Index, known as Trans log Index, may be used. This assume that a Translog function 25 describes, the relationship between 'Y', 'K', ‘L', ‘M’, ‘E’ and 'T' (production function) and also the relationship between the aggregates and components Constant returns to scale are assumes for all these functions. The Translog production function is

$$\text{Log Y} = \alpha_0 + \alpha_K \log K + \alpha_L \log L + \alpha_M \log M + \alpha_E \log E + \alpha_T T + \frac{1}{2}\beta_{KK} (\log K)^2 + \beta_{KL} (\log K)(\log L) + \beta_{KM} (\log K)(\log M) + \beta_{KE} (\log K)(\log E) + \frac{1}{2}\beta_{LL} (\log L)^2 + \beta_{LM} (\log L)(\log M) + \beta_{LE} (\log L)(\log E) + \frac{1}{2}\beta_{MM} (\log M)^2 + \beta_{ME} (\log M)(\log E) + \frac{1}{2}\beta_{EE} (\log E)^2 + \frac{1}{2}\beta_{TT} T^2$$

Equation (26)

In above α and β are the parameters of the production function and the rate of change of the total factor productivity is indicated by β_{TT} T^2. Further, the elasticity of output with respect to labour capital, material and energy is indicated by

$$\frac{d \log Y}{d \log L} = \alpha L + \beta_{LL} \log L + \beta_{LT} \log T + \beta_{KL} \log K + \beta_{LM} \log M + \beta_{LE} \log E$$

$$\frac{d \log Y}{d \log K} = \alpha K + \beta_{KK} \log K + \beta_{KT} \log T + \beta_{KL} \log L + \beta_{KM} \log M + \beta_{KE} \log E$$

$$\frac{d \log Y}{d \log M} = \alpha M + \beta_{MM} \log M + \beta_{MT} \log T + \beta_{KM} \log K + \beta_{LM} \log L + \beta_{ME} \log E$$

$$\frac{d \log Y}{d \log E} = \alpha E + \beta_{EE} \log E + \beta_{ET} \log T + \beta_{KE} \log K + \beta_{LE} \log L + \beta_{ME} \log M$$

Respectively constant return require

$\alpha_K + \alpha_L + \alpha_M + \alpha_E = 1$; $\beta_{LL} + \beta_{KL} + \beta_{LM} + \beta_{LE} = 0$; $\beta_{KK} + \beta_{KL} + \beta_{KM} + \beta_{KE} = 0$; $\beta_{MM} + \beta_{KM} + \beta_{LM} + \beta_{ME} = 0$; $\beta_{EE} + \beta_{KE} + \beta_{LE} + \beta_{ME} = 0$

Corresponding to the equation (10) we get

$\Delta \log Y = V_K (\Delta \log K) + V_L (\Delta \log L) + V_M (\Delta \log M) + V_E (\Delta \log E) + V_T$ Equation (27)

Where

$\Delta \log Y = \text{Log } Y_{(T)} - \text{Log } Y_{(T-1)}$ Equation (28)

$\Delta \log K = \text{Log } K_{(T)} - \text{Log } K_{(T-1)}$ Equation (29)

$\Delta \log L = \text{Log } L_{(T)} - \text{Log } L_{(T-1)}$ Equation (30)

$\Delta \log M = \text{Log } M_{(T)} - \text{Log } M_{(T-1)}$ Equation (31)

$\Delta \log E = \text{Log } E_{(T)} - \text{Log } E_{(T-1)}$ Equation (32)

And

$V_{L(T)} = \frac{1}{2} [V_{L(T)} + V_{L(T-1)}]$ Equation (33)

$V_{K(T)} = \frac{1}{2} [V_{K(T)} + V_{K(T-1)}]$ Equation (34)

$V_{M(T)} = \frac{1}{2} [V_{M(T)} + V_{M(T-1)}]$ Equation (35)

$V_{E(T)} = \frac{1}{2} [V_{E(T)} + V_{E(T-1)}]$ Equation (36)

V_L = Average of the share of labour
V_K = Average of the share of capital
V_M = Average of the share of material
V_E = Average of the share of energy

The equation (27) for V_T is termed the avenge Translog quantity index of technological change 'Δ log Y', 'Δ log K', 'Δ log L', 'Δ log M' and 'Δ log E' obtain as weighted average of the rates of growth in their composition. Assuming the condition of competitive equilibrium, the above mention Translog production function that is equation (26) can be used to derive the Translog measure of Total Factor Productivity Growth.

$$\text{Ln}\left(\frac{TFP_t}{TFP_{t-1}}\right) = \left[Ln\left(\frac{Y_t}{Y_{t-1}}\right)\ \right] - \ V_K\left[Ln\left(\frac{K_t}{K_{t-1}}\right)\right] - V_K\left[Ln\left(\frac{L_t}{L_{t-1}}\right)\right] - \ V_K\left[Ln\left(\frac{M_t}{M_{t-1}}\right)\right] - V_K\left[Ln\left(\frac{E_t}{E_{t-1}}\right)\right] \qquad \text{Equation (37)}$$

Using the equation 37, the growth rates of TFP have been calculated for each year. These have then been used to obtain an index of TFP in the following way. Let index of TFP is denoted by A. The index for the base year, A_0, is taken as 100. Then, the index for subsequent years is calculated using the following equation:

$$\left(\frac{A_t}{A_{t-1}}\right) = \exp\ (\Delta \ln TFP_t) \qquad \text{Equation (38)}$$

Having obtained the TFP index for different years, estimates of TFP growth rate have been made for two sub-periods, 1975-76 to 1990-91 and 1990-91 to 2011-12, and for the entire period 1975-76 to 2011-12. The estimation of TFP growth rate for the entire period has been done by fitting an exponential (or semi-log) trend equation to the TFP index.

The present study uses the Translog production function for analysing the factor productivity in manufacturing sector at aggregate level. The advantage of the Translog index is that it does not require technological progress to be Hicks-neutral. Most of the recent studies on the measurement of productivity in the Indian industries have undertaken discrete approximation of the Translog Production Function in the form of Translog Index. The Translog index provides an estimate of the shift of the production function even if technological change is non-neutral. Appendix 3.1 shows the alternative methods to measure total factor productivity.

Advantage of Translog Index of TFP: The Translog index of TFP is a discrete approximation to the Divisia index of technical change. It has the advantage that it does not make rigid assumption about elasticity of substitution between factors of production (as done by Solow index). It allows for variable elasticity of substitution. Another advantage of Translog index is that it does not require technological progress to be Hicks- neutral[1] The Translog provides an estimate of the shift of the production function if the technological change is non-neutral. The partial factor productivity is calculated by dividing the total output by the quantity of an input.

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[1]Technical progress where with any given factor proportions the average and marginal products of all factors increase in the same proportion.

The main problem of using this measurement of productivity is that it ignores the fact that productivity of an input depends on level of other inputs used. The TFP approach overcomes this problem by taking into account the levels of all the inputs used in the production of output. Therefore, in this study, along with partial productivity growth, TFPG is estimated under four input framework applying Translog index of TFP.

3.1.2 Data Description and Definition of Variables

An attempt is made to provide an in-depth look at the trends in productivity growth in the Indian manufacturing sector. This study consider a set of 22 two digit manufacturing industries Registered (Organised) manufacturing sector: The registered manufacturing sector includes all factories covered under sections 2m (i) and 2m (ii) of the Indian Factories Act (IFA), 1948 which refers to the factories employing 10 or more workers and using power or those employing 20 or more workers but not using power on any day of the preceding 12 months, and in any part of which a manufacturing process is being carried on with the aid of power, or is ordinarily carried on so; or (b) whereon twenty or more workers are working or were working on any day of the preceding twelve months and in any part of which a manufacturing process is being carried on without the aid of power, or is ordinarily carried on so. It excludes the following non-manufacturing sectors from the analysis: (i) Agriculture, hunting & related service activities, (ii) Other mining and quarrying, (iii) Recycling and (iv) Other industries. The period of analysis is 1975-76 to 2011-12. Selection of time period is largely guided by availability of data. Table 3.2 shows the industries covered in the study.

It may be noted that till 1989-90 the classification of industries followed in Annual Survey of Industries (ASI) was based on the national industrial classification 1970 (NIC-1970). The switch to the NIC-1987 from the year 1989-90 necessitated some matching of the NIC-1970 with NIC-1987, after that NIC-1987 switch to the NIC-1998 from NIC-1987. We treated the NIC-1998 as the base and accordingly carried out data adjustment at the 2-digit industry level. Data on different variables from 2004-05 to 2007-08 and 2008-09 to 2011-12 was recorded as per NIC-2004 and NIC-2008, respectively. For more detail see Appendix 1.2 for adjustment of National Industry Classification after 2003.

Table 3.2: List of manufacturing industries covered in the study

Sr. No.	NIC Code 1998	Name of the Manufacturing Industry
1	15	Manufacture of Food Products and Beverages
2	16	Manufacture of Tobacco Products
3	17	Manufacture of Textiles
4	18	Manufacture of Wearing Apparel Dressing and Dyeing of Fur
5	19	Tanning and Dressing of Leather Manufacture
6	20	Manufacture of Wood and Products of Wood and Cork
7	21	Manufacture of Paper and Paper Products
8	22	Publishing, Printing and Reproduction of Recorded Media
9	23	Manufacture of Coke, Refined Petroleum Products and Nuclear Fuel
10	24	Manufacture of Chemicals and Products
11	25	Manufacture of Rubber and Plastic Products
12	26	Manufacture of Other Non-Metallic Mineral Products
13	27	Manufacture of Basic Metals
14	28	Manufacture of Fabricated Metal Products
15	29	Manufacture of Machinery and Equipments
16	30	Manufacture of Office, Accounting & Computing Machinery
17	31	Manufacture of Electrical Machinery and Apparatus N.E.C.
18	32	Manufacture of Radio, Television and Communication Equipments and Apparatus
19	33	Manufacture of Medical, Precision and Optical Instruments, Watches and Clocks
20	34	Manufacture of Motor Vehicles, Trailers and Semi-Trailers
21	35	Manufacture of Other Transport Equipment
22	36	Manufacture of Furniture; Manufacturing N.E.C.

Real output and input series have been constructed for aggregate manufacturing for the period 1975-76 to 2011-12. Rates of TFP growth have been computed for the sub-periods, 1975-76 to 1990-91 (pre-reform period) and 1991-92 to 2011-12 (post-reform period). For detail investigation of TFPG of different industries during the same period, this study compares five years TFPG of each industries.

For correcting the reported data on nominal gross output and intermediate inputs, suitable deflators have been constructed with the help of the official series on wholesale price indices. For the purposes of deflating the material and energy inputs, we needed to create a weighted price index. For more detail see Appendix 3.3. (Index of Number of Wholesale Prices in India, prepared by the Office of the Economic Advisor, Ministry of Industry, Government of India).

3.1.3 Definition of Variables

The ASI definition of variables which is used in the present study areas under:

(1) Fixed Capital: Fixed capital includes factory land improvement in it and other construction, building, plant and machinery, miscellaneous assets like furniture and fixtures, fitting, transport equipment, tools and other fixed assets having a normal productive age of more them a year and assets under construction installation. These are net of depreciation.

(2) Working Capital: Working capital includes stock of materials, fuel, stores, etc. finished and semi-finished goods, cash in hand and at bank, and net balance of amount receivable over the amount payable for the accounting year. The data on capital items are given in terms of book values of capital assets net of cumulative depreciation.

(3) Worker: A worker is defined as a person employed, directly or through an agency, whether for wages or not, in any manufacturing process or in cleaning any part of machinery or promises used for a manufacturing process, or in any other kind of work, incidental to, or connected with the manufacturing process, but exclude persons holding positions of supervision or management of employed in a confidential position.

(4) ***Persons other than Workers:*** Persons other than workers include persons holding supervisory and managerial positions, clerks in administrative office, stores and welfare section, match and ward staff.

(5) ***Total Employees:*** Apart, from workers and persons other than workers total employees include unpaid, working proprietors (in case of cooperative factory. working members), family workers, etc. (if paid these are included in the categories of workers or persons other than workers.

(6) ***Total Emoluments:*** Remuneration to employees given under two hands, wages and salaries and total emoluments. Data on both heads are provided for workers as well as total employees (except some years when data on total emoluments are given for total employees only). Besides wages and salaries and bonus, total emoluments include imputed value of benefits in king, old age benefits, social security and other benefits.

(7) ***Total Inputs:*** Total inputs include power, fuel and materials consumed, and work done for the factory by other concerns. Inputs are inclusive of transportation changes, agent's commission, taxes and duties.

(8) ***Depreciation:*** Depreciation is calculated at the rates allowed by income tax authorities for assessing taxable income. This rate varies according to the type of asset and industry.

(9) ***Value Added:*** Value added by manufacture if derived by deducting total inputs and depreciation from total output. Gross ex-factory value of output comprises value of products and by-products' , net value of semi-finished goods, value of industrial or non-industrial services rendered to others and net balance of goods sold in the same conditions as purchased, etc. This is net of excise duty paid or sales tax released (by the factory on behalf of government), transport changes from factory and selling agents commission.

(10) ***Fuels & Materials:*** Fuels and Materials consumed: This category excludes any fuel or materials manufacturing within the factory and consumed. It does not includes the cost

of transport of materials, fuels etc. to the factory, commission of purchasing agents etc. where these are not included in the reported value.

3.1.4 Construction of Variables

The basic variables for the estimation of the yearly TFP growth rates are gross output, capital stock, number of workers employed, materials consumed and energy consumed. To reach at the measures of output and inputs in real terms, appropriate deflators for the variables were constructed. This study use data form Annual Survey of Industry to find out TFP growth rates of manufacturing sector.

Output

For correcting the reported data on nominal gross output and intermediate inputs, suitable deflators have been constructed with the help of the official series on wholesale price indices. For the purposes of deflating the material and energy inputs, we needed to create a weighted price index. (Index of Number of Wholesale Prices in India, prepared by the Office of the Economic Advisor, Ministry of Industry, Government of India). It was difficult to get an entirely satisfactory deflator for each of the 22 two-digit industries from the wholesale price statistics. Therefore for except few industries we were required to construct a weighted average combining wholesale price indices to arrive at a reasonably accurate deflator for the concerned industry.

One of the important advances in the industry-level productivity measurement has been to utilize gross output rather than value-added as a measure of product at the industry level, Jorgenson argues that an important advantage of focusing on industry gross output for growth accounting is that intermediate inputs can be treated symmetrically with inputs of capital and labour. A study by Balakrishan and Pushapangadan (1994) has shown that a gross value added measure using a single deflation procedure might produce a bias in the estimates if material prices do not move parallel to output prices. The present study is used double deflation method and prepares separate series by constructing an appropriate WPI series thereafter deflate the gross output and input series.

Labour

There are various arguments put forward while specifying a measure of labour inputs. Total persons engaged in industrial units are used as the measure of labour input. For recent issues, it is reported in the ASI under the head "persons engaged", for earlier issue it is reported as "number of employees". This relates to all persons engaged by the factory for wages or not in work directly connected or indirectly with the manufacturing process and includes administrative, technical, clerical staff as also labour used in production of capital assets for factory's own use. Implicit in such a measure is the assumption that workers and other than workers are perfect substitutes.

Capital

The measurement of capital stock is the most complex of all input measurements. The conceptual problems involved in the measurement of capital input have been widely discussed by writers on productivity study. Given the theoretical reservations, there are also wide differences in the actual methodology used to build the estimates of capital stock. The most widely used procedure is that of the "perpetual inventory method". Gross fixed capital series at constant prices was derived using the perpetual inventory method. To arrive at the real gross fixed capital stock, we need

- An estimate of benchmark gross fixed capital stock
- Time series on gross investment and
- Time series of capital goods price

The benchmark gross fixed capital stock for the two digit industries for the year 1973-74 is arrived at by multiplying the net fixed capital stock as reported in the ASI by the gross-net ratios as available from Hashim and Dadi (1970)[2]. The gross net ratios were available for some broad industries necessitating mapping between the two digit sectors, see Appendix 3.4 for detail mapping between two digit sector form three digit sector.

The benchmark of real capital stock is computed by inflating with the average of the capital goods price for the period 1973-74 to 2011-12. For each industry, the yearly gross investment

[2] An alternative would have been to consider the gross-net ratios available from an RBI Bulletin.

in current prices was computed, from the figure of book values of net fixed capital assets and depreciation reported in ASI. Gross investment in year t denoted by $I_{(t)}$ is computed as $I_{(t)}= B_{(t)} – B_{(t-1)} + D_{(t)}$, where $B_{(t)}$ is the book-value of fixed assets in year t and $D_{(t)}$ is depreciation of fixed assets in year t, both as reported in ASI.

The yearly gross investment is deflated by an index of capital goods price series with 2004-05 =100 as base to arrive at a real gross investment series. Time series data on gross output, costs of intermediate inputs- materials as well as energy and current price of gross fixed capital stock have been deflated by suitable deflators (base 2004-05 =100). The post benchmark real fixed capital stock is arrived at by the following procedure:

Real gross fixed capital stock (t) = Real gross fixed capital stock (t-1) + Real gross investment (t)

Gross Output:

It was difficult to get an entirely satisfactory deflator for each of the 22 two-digit industries from the wholesale price statistics. Therefore for except 2 or 3 industries we were required to construct a weighted average combining wholesale price indices to arrive at a reasonably accurate deflator for the concerned industry.

Gross Fixed Capital Stock:

A price deflator for capital goods is needed to deflate the yearly gross investment series. For our study, fixed capital was two types: (1) structures and (2) equipment. We use construction and machinery and equipment to proxy for structures and equipment. The implicit price deflator for investment in construction and machinery and equipment (base 2004-05 = 100) is used to deflate the current rupee investment series. The price deflator is computed as the ratio of current price gross capital formation by type of assets to constant price gross capital formation by type of assets. The industry specific shares of buildings and plant & machinery in the total are used as weights for structures and equipment in computing a weighted implicit price deflator (Das 2003).

Material

To compute a price series of material inputs, the present study uses all commodities weighted average wholesale price indices for deflating the material input series.

Energy

For the purposes of our study, the energy input comprises the following types: (1) Coal, (2) Natural gas (or petroleum) and (3) electricity. For the purposes of deflating the material and energy inputs, we needed to create a weighted price index. For this purpose, the appropriate weights were taken from the WPI prepared by the Office of the Economic Advisor, Ministry of Industry, Government of India. Since the breakup according to these categories was not available from the ASI database, the wholesale price indices (base 2004-05) of coal, mineral oil and electricity were used for the three types of energy input.

3.2. Causality Test between Total Factor Productivity, Growth Rate of Output and Real Effective Exchange Rate

As mentioned before, the purpose of this study is to establish if the real effective exchange rate influences in any way the total factor productivity and growth rate of output of manufacturing industry or if total factor productivity has an impact on the real effective exchange rate and growth rate of output or growth rate of output has an impact on the real effective exchange rate and total factor productivity. In order to empirically do this, a series of tests will be used. These tests are described in the following in the order they are employed.

The first step is to examine the time-series property of stationarity. To do this the Augmented Dickey-Fuller (1979) unit-root test[3] will be used with the null hypothesis of non-stationarity i.e. existence of unit-root. In addition to the regular ADF test I will use the Elder & Kennedy strategy,[4] in which a trend component and an intercept will be included. In case one or more of the series is not stationary it will be further tested to check if there is a stochastic or deterministic trend.

[3] Phillips and Perron (1988) have developed a more comprehensive theory of unit root non-stationarity. The tests are similar to ADF tests. The Phillips-Perron (PP) unit root tests differ from the ADF tests mainly in how they deal with serial correlation and heteroskedasticity in the errors. The tests usually give the same conclusions as the ADF tests.

[4] Elder and Kennedy (2001) present a simple testing strategy that avoids double and triple testing for the unit root that can occur with other testing strategies, and discusses how to use prior knowledge about the existence or not of long-run growth (or shrinkage) in variable.

In the augmented Dickey-Fuller test it is assumed that the error terms (ε_t) are correlated and the main principle of the test is that it is conducted by augmenting the Dickey-Fuller test using k lags of the dependable variable. An important practical issue for the implementation of the ADF test is the specification of the lag length. If lag length is too small, then the remaining serial correlation in the errors will bias the test. If p is too large, then the power of the test will suffer. The model can be written as:

$$\Delta Y_t = \alpha + \beta\, t + \gamma\, Y_{t-1} + \delta_i \sum_{\delta=1}^{i} Y_{t-i} + \varepsilon_t \qquad \text{Equation (39)}$$

Where α is a constant, β is the coefficient on a time trend, i is the lag of order of the auto-regressive process and ε_t is a pure white noise error term. The numeric value of i is determined using Akaike Information Criterion.

When testing for unit roots it is necessary to have a testing strategy. In this study the Elder and Kennedy strategy will be employed. Moreover this strategy rules out some types of unrealistic or implausible outcomes for economic time-series processes such as the co-existence of a unit root and a deterministic trend. The null hypothesis of this test is that a unit-root exists, meaning that $\gamma= 0$. The alternative hypothesis is that no unit-root exists in the series which implies $\gamma < 0$. If the test statistic is less than the critical value then the null hypothesis is rejected, no unit root is present and the time-series is stationary.

In case that all the variables are integrated of the same order a cointegration test should be used in order to check if any cointegrating relationship exists between the variables. Because the variables utilized in this study have different integration orders, it is not necessary to apply this test.

Since the purpose of this study is to analyze aspects of the relationships between real effective exchange rate influences in any way the total factor productivity and growth rate of output of manufacturing industry, the multi-variate Vector Autoregressive (VAR) model[5] is appropriate to use since it represents the correlations among a set of variables.

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[5] The vector autoregression (VAR) is an econometric model used to capture the linear interdependencies among multiple time series. VAR models generalize the univariate autoregressive model (AR model) by allowing for more than one evolving variable. All variables in a VAR are treated symmetrically in a structural sense (although

The first step in estimating a multi-variate VAR model is to determine the optimal lag-length order. In order to do so study employed the Akaike Information Criterion. Even though we have used AIC and SC to aid in the choice of lag length, we have estimated the model using several different lag structures to ensure that results are not sensitive to the choice of the lag length.

The general formula that is going to be used for the multi-variate VAR (k) model is as follows:

$TFP_t = c_1 + \alpha_{11}TFP_{t-1} + \alpha_{12} TFP_{t-2} + \ldots + \alpha_{1k} TFP_{t-k} + \beta_{11} GRO_{t-1} + \beta_{12} GRO_{t-2} + \ldots + \beta_{1k} GRO_{t-k} + \delta_{11} REER_{t-1} + \delta_{12} REER_{t-2} + \ldots + \delta_{1k} REER_{t-k} + \varepsilon_{1t}$ Equation (40)

$GRO_t = c_2 + \alpha_{21}TFP_{t-1} + \alpha_{22} TFP_{t-2} + \ldots + \alpha_{2k} TFP_{t-k} + \beta_{21} GRO_{t-1} + \beta_{22} GRO_{t-2} + \ldots + \beta_{2k} GRO_{t-k} + \delta_{21} REER_{t-1} + \delta_{22} REER_{t-2} + \ldots + \delta_{2k} REER_{t-k} + \varepsilon_{2t}$ Equation (41)

$REER_t = c_3 + \alpha_{31}TFP_{t-1} + \alpha_{32} TFP_{t-2} + \ldots + \alpha_{3k} TFP_{t-k} + \beta_{31} GRO_{t-1} + \beta_{32} GRO_{t-2} + \ldots + \beta_{3k} GRO_{t-k} + \delta_{31} REER_{t-1} + \delta_{32} REER_{t-2} + \ldots + \delta_{3k} REER_{t-k} + \varepsilon_{3t}$ Equation (42)

Where *k* is the order of the VAR, *a* is the constant term, *ε* is an error term, *TFP* is Total Factor Productivity of manufacturing sector, *GRO* is the Growth Rate of Output and *REER* is the Real Effective Exchange Rate in India. The model above explains the relationship between the real exchange rate and one of the four proxies for economic growth.

After estimating the model we need to make sure the residuals are white noise. If there is white noise, the residuals are completely randomly scattered with no systematic pattern which means that the model is correctly specified and the residuals do not include any information that is not included in the regression. To establish if the residuals are white noise the proper-ties of autocorrelation and normality are tested.

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the estimated quantitative response coefficients will not in general be the same); each variable has an equation explaining its evolution based on its own lags and the lags of the other model variables.

To examine if there is autocorrelation the Breusch-Godfrey serial correlation Lagrange multiplier test is used. The test will establish if there is any autocorrelation in the errors of the regression model. The null hypothesis is that there is no serial correlation of any order up to the specified number of lags and the alternative hypothesis states that there is autocorrelation be-tween the residuals.

In order to see if the residuals are normally distributed the Jarque-Bera normality test is employed. It tests whether the data has skewness and kurtosis matching a normal distribution. The null hypothesis is a joint hypothesis of the skewness being zero and the excess kurtosis being also zero, in other words the null hypothesis states that the data follows a normal distribution. Of course, the alternative hypothesis is that the sample data does not follow a normal distribution.

The next step after estimating the models and checking the residuals is to test the direction of the causality using Granger causality test (Granger, 1969). Granger causality is a statistical concept of causality that is based on prediction. According to Granger causality, if a signal X_1 "Granger-causes" a signal X_2, then past values of X_1 should contain information that helps predict X_2 above and beyond the information contained in past values of X_2 alone. Its mathematical formulation is based on linear regression modeling of stochastic processes. By doing so, the relationship between the variables when they are causing each other can be observed. When we run the Granger causality test, there are four possible outcome can be anticipate (Gujarati, 2004)[6]:

1. If *X* causes *Y*, coefficient on the lagged *X* should be significant in the equation for *Y* and it can be said that *X* Granger causes *Y*, i.e. coefficients on the lagged X are statistically different from zero as a group and the set of estimated coefficients on the lagged Y are not statistically different from zero.
2. If *Y* causes *X*, coefficient on the lagged *X* should be significant in the equation for *Y* and it can be said that *X* Granger causes *Y*, i.e. coefficients on the lagged X are not statistically different from zero as a group and the set of estimated coefficients on the lagged Y are statistically different from zero.

[6] For more detail of Granger Causality Test, read “Basic Econometrics” by Damodar N. Gujarati, The McGraw-Hill Companies, Inc., New York.

3. If both variables cause each other it can be said that there is a “bi-directional causality” or “bi-directional feedback”, the coefficients are statistically significantly different from zero in each regressions.
4. If neither set of lags are statistically significant in the equation for the other variable it can be said that *X* and *Y* are independent, the coefficients are not statistically significant in each regressions.

Yearly data have been used for analyzing causality between Growth Rate of Output, Total Factor Productivity Growth and Real Effective Exchange Rate. To begin with, we convert them into natural logarithmic form for reducing variations in them.

Then five different criteria viz. LR (Sequential modified Likelihood Ratio test statistic (each test at 5% level), FPE (Final Prediction Error), AIC (Akaike Information Criterion), SC (Schwarz Information Criterion) and HQ (Hannan-Quinn Information Criterion) have been used to select the appropriate lag order. For the lag order thus selected, pairwise Granger Causality test has been performed with a pair of Null Hypotheses viz. REER does not Granger cause GRO, GRO does not Granger cause TFP, TFP does not Granger cause REER and other way around. This analysis is carried out for three time period- 1975-76 to 1990-91, 1990-91 to 2012 and 1975-76 to 2011-12. Depending upon the values of F-statistic and the associated significance levels, appropriate conclusions are drawn. The entire data analysis was done using the software ‘E-views 7.0’

3.3. Multi-variate Regression Analysis between TFPG and Independent Variables

Multi-variate regression analysis is applied to analyze the variation in TFPG of different industry groups. Productivity Growth Rates (PGR) are computed for twenty two industry groups during 1975-76 to 2011-12 and treated as dependent variable. The regression equation specified as follows:

$TFPG_t = F(Y/N_t, CR_t, K/L_t, NP_t, W_t, ERP_t, ICR_t, IPR_t, REER_t, u_t)$

Where t = time period. Total number of Indian manufacturing industries = 22
Y/N_t is output per factory is taken as a measure of firm size.

CR_t is concentration ration of a particular industry group captures the effect of market structure on TFPG.

K/L_t is the capital-labour ratio serves as technological variable.

NP_t is the non-production employee per production worker is also a technological variable and is related to the composition of work force.

W_t is the real wage rate

ERP_t is the effective rate of protection

ICR_t is the import coverage ration

IPR_t is the Import Penetration Ratio

$REER_t$ is the Real Effective Exchange Rate

Output per factory:

Output per factory (Y/N) is taken as a measure of firm size. Theoretically there are two broad ways by which firm size affects industrial performance. With capacity diversification and capital utilization, a larger firm can be able to exploit economies of scale and generate higher TFPG relative to smaller firms. Alternatively, since size is correlated with market power and market power helps to develop X-inefficiencies[7], it can lead to comparatively inferior performance. Firm size heterogeneity is widespread among developing countries. However, theoretically both small and large firms have productivity advantages and disadvantages such as scale economies vs. smaller and more flexible management structure. Therefore, theory does not show any bias toward larger firm or smaller firm to boost TFP growth rate. In the context of Indian manufacturing, it appears, the relationship between productivity growth and output growth through the lowering of costs and prices will be much weaker than the relationship resulting from differential technological progress and scale economies, with the consequence that the use of output growth as an explanatory variable of TFP growth. The perusal of the empirical literature on this issue [Mukherjee (1963), Goldar (1986), Ahluwalia (1991), Topalova (2004), Prabal and Nagaraj (2010), Ghose and Biswas (2010)] suggests that these studies vary both with respect to choice of the indicators specifying firm size and the conclusions arrived at regarding the positive, negative or no impact of firm size on TFPG.

[7] With market forms other than perfect competition, such as monopoly or oligopoly, productive inefficiency can persist, because the lack of competition makes it possible to use inefficient production techniques and still stay in business and produce. However, X-inefficiency focuses on productive efficiency and minimising costs rather than maximising welfare and allocative efficiency.

Concentration Ratio:

Concentration ratio (CR) of a particular industry group captures the effect of market structure on TFP growth. A concentration ratio is the ratio of the combined market shares of a given number of firms to the whole market size. The effect of CR is expected to be negative by some researchers because competition may lead to cost consciousness and drive for technological advancement. In spite of the vagueness of theoretical predictions, many studies have tried to test the hypothesis that market structure and higher productivity. Empirically, the degree of competition has been captured by a number of variables; concentration ratio, above usual rent, market share and questionnaire based results. A connection between concentration ratio and productivity is based on the assumption that as the market gets concentrated, a higher concentration is expected to be associated with lower productivity. The manager of a company, registering high above normal rent may feel a lesser volume of competitive pressure and thus make less effort and eventually it leads to low productivity. If a firm has a small market share, the manager of a firm with a smaller market share may feel more competitive pressures, and make more efforts to increase productivity[8].

There may be advantages of large size, protected market and a positive relationship between CR and TFP growth is to be anticipated. Although there are advantages of big size and secured market for innovation, an industry which has a relatively high degree of concentration need not experience a relatively high growth rate in TFP. In a situation that is less competitive there is less inducement to reduce cost and improve technology. Thus, TFP growth rate will vary directly or inversely with the degree of concentration[9] depending on the relative strength of these two opposing forces.

The present study uses Gini-Hirschman coefficient of industrial concentration to compute industrial CR, the formula is:

[8] For detail justification between Concentration ratio and productivity see "Product Market Competition and Productivity in the Indian Manufacturing Industry" by Kato Atsushi

[9] Gopinath at el. found an inverted U-shape relationship between TFP growth and concentration. At initial stage there is a positive association between TFP growth and concentration after a point, there is a negative relation found between the two variables.

$$GH = \sqrt{\sum_{i=1}^{n} Y_{it}^{2}}$$ Equation (43)

Y = market share of ith firm in period t.

Capital-Labour Ratio:

In appraising the effect of capital formation of labour productivity, it is useful to discuss the growth of the capital/labour ratio to link the descriptive measures of growth of the capital stock and the more inferential quantitative assessment of the contribution of capital formation to growth in labour productivity. Capital-labour ratio (K/L) serves as technological variable. Capital-labour ratio is calculated as the ratio between net fixed capital stock to total number of workers in a particular two-digit level industry.

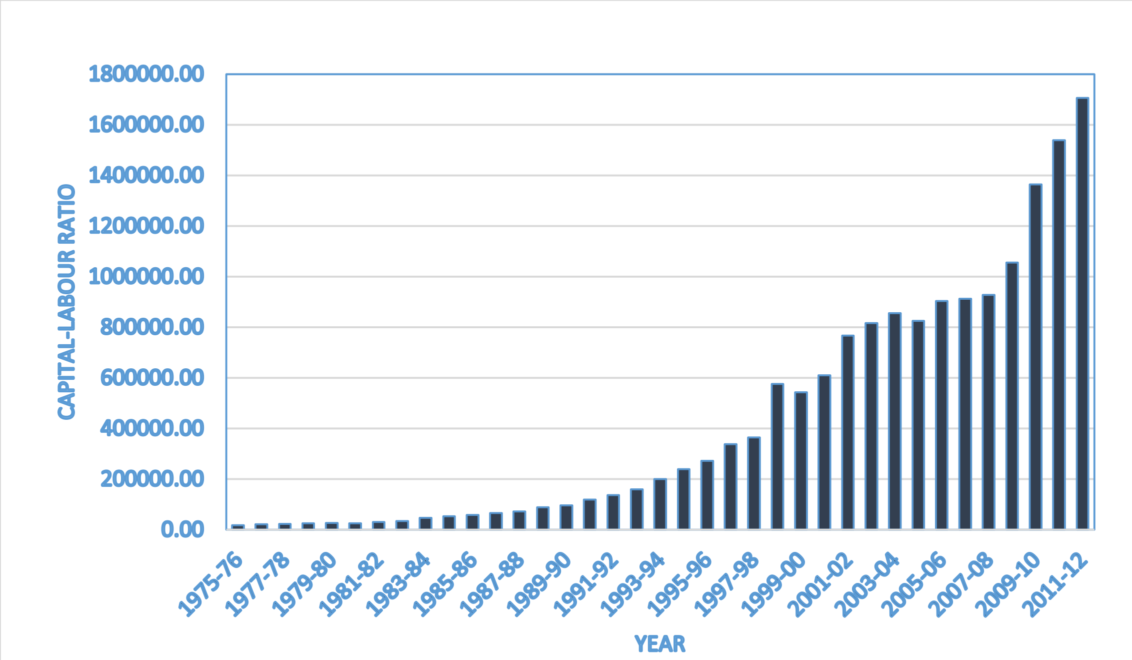
$$\frac{K}{L} = \frac{Net\ Fixed\ Capital\ Stock}{Number\ of\ Workers}$$ Equation (44)

Growth in Capital-labour ratio has been used in many studies as a measurement of technological progress. According to Marx and Kuznets, with economic development, labour productivity and capital-labour ratio would increase. In the Marxian pattern capital-labour ratio would increase faster than labour productivity implying rising capital-output ratio that is, falling capital productivity. The conventional capital - labour ratio gives an idea about the relative degree of mechanization. Normally, it is expected that there exists positive relationship between K/L and TFPG. Goldar (2004) in his study found a smaller difference in the estimated growth rate in capital-labour ratio in the post-reform period.

The partial factor productivities are dominantly affected by the trends in factor intensity, i.e. the capital-labour ratio is increasing over time, and the analysis of partial productivity changes would overstate the increase in labour productivity and understate the increase in capital productivity. “The dominant feature that emerges from the analysis of the long-term trends in partial factor productivities in the manufacturing sector is that of a sharp increase in capital intensity accompanied by falling capital productivity (i.e. rising capital-output ratio) and moderately rising labour productivity”. Figure 3.1 show the capital-labour ratio of organised manufacturing sector in India. Capital-labour ratio increase gradually upto 1995-96 but after

1996-97 there is a drastic increase in the capital labour ratio it shows manufacturing sector adopt greater amount of capital in the production process.

Figure 3.1: Capital-Labour ratio of organized manufacturing sector



Source: Author’s estimation (based on ASI data)

Non-Production Employee per Production Worker

Non-production employee per production worker (NP) is measured skill intensity and also a technological variable. It is a term that is related to the composition of work force. A higher degree of bureaucratic control is observed when there are a higher number of employees per worker. It can hinder productivity of the particular industry. Moreover, recruitment of non-production employees is in accordance to the political pressure exuded by the ruling party to provide employment to its party forces. Such employees often are a hindrance to the industry’s productivity. Following are the formula to calculate NP:

$$\text{NP} = \frac{Non-Production\ Employees}{Number\ of\ Workers} \qquad \text{Equation (45)}$$

So in the words of Sunil Kumar (2001), such a line of reasoning postulated a negative relation between NP and TFPG. On the other hand, a positive relation between NP and TFPG indicates that the combination of work force is just right to operate efficiently and to promote growth in TFP of different industries.

Real Wages

Real Wages (W) is considered as determinants of TFPG. Banga (2005), Das (2008), Patra and Nayak (2012) and Paul (2014) found there is a positive relationship between real wage rate and productivity growth. Labour productivity is expected to play a significant role in determination of industrial real wages. Paul in his study found that there exists a direct relationship between wages and productivity, which is linked to value addition by a firm and process of substitution between labour and capital. If W is appropriately high for any industry group, at that time skilled workers can be attracted towards that industry and considering skill as a positive determinants of TFPG, it can be argued that as real wage increases through the involvement of skilled workers in the production process productivity can increase. It may also be possible that TFPG is associated with changes in real wage rate. Following are the formula to find out real wages.

$$\text{RW} = \frac{Wages\ to\ Worker}{Consumer\ Price\ Index\ for\ Industrial\ Workers} \qquad \text{Equation (46)}$$

Effective Rate of Protection

In developing countries like India, trade interventions are of two types: tariff and non-tariff barriers. A tariff and non-tariff barriers increase for a product, results in a decrease in imports of the product and an increase in the output of domestic industry. Tariffs continue the most extensively used instrument of trade policy in both developing and developed countries. A tariff is an indirect tax on imports and is usually set by the government and is published in the tariff schedules. Tariff rates therefore indicate to an extent the degree of protection of the domestic industry from international competition and stands as a good chance to be considered as an indicator of trade policy orientation. As a presence of non-tariff barriers, tariffs generally do not reflect the actual level of protection of the domestic industries.

In addition, the nominal rates of tariff, by not taking account of how protection on intermediate products affects the incentive structure, do not accurately portray the degree of protection (Das, 2003). Therefore, even if nominal rates would be a good measure of liberalization in the sense that their use must decline as a trade policy instrument over time, they do not reflect the decrease in actual levels of protection to the domestic industry. More specifically, nominal tariffs do not give any idea about tariff escalation, i.e. tariffs which increase with the stage of production. In particular, it disregards the fact that the degree of protection conferred on an activity will depend not only on any interventions which affect the price of the final good produced, but also by any interventions which affect the price paid for inputs into the production process (Homagni, 2010). When this is the case, the rate of effective protection exceeds the nominal tariff rate.[10]

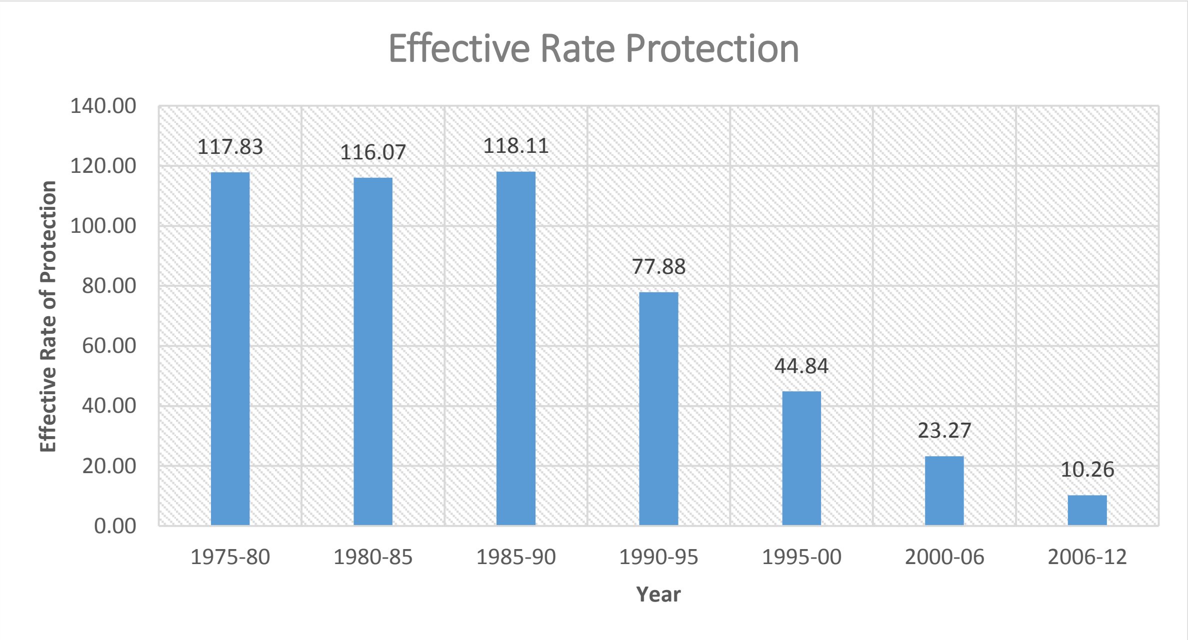
In spite of the powerful nature of ERP to reflect the levels of protection of domestic industry, it is to be noted that, ERP calculations are not free from measurement complications and problems of data availability. Greenaway and Milner (1993) highlights few such complications, most of which it points out to be 'study specific', which include choice of tariffs (like ex-ante or ex-post), tariff averaging, input-output coefficients, choice of non-traded inputs, import content of non-tradables, non-tariff barriers, exchange rate effects and the like (Choudhury, 2010).

Further, the nominal protection rate neglects the fact that the degree of protection conferred on an activity will depend not only on the any interventions which affect the price of the final good produced, but also by any interventions affect the price paid for inputs which is imported for the production process. The Nominal Rate of Protection (NRP) of a commodity is defined as the percentage excess of domestic price over world market price resulting from protective measures. If tariffs are the only source of protection, then the NRP is the tariff rate itself. Figure 3.2 show the rate of change in effective rate of protection over the period of 1975-76 to 2011-12. Indian manufacturing sector enjoyed a very high degree of protection from import competition because of a very high rate of tariff imposed by the government as well as extensive quantitative restrictions on imported goods. Trade reform initiated in 1991, prior to

[10] Calculation of the rate of effective protection is on the domestic value added, whereas calculation of the nominal tariff rate is on the value of the final commodity. Domestic value added equals the price of the final commodity minus the cost of the imported inputs going into production of the commodity.

this, effective rate of protection about 117 percent from 1975-76 to 1990-91. The tariff rate were reduced considerably in 1990s and 2000s. Effective rate of protection were reduced from 118.11 percent in 1985-90 to 77.88 percent and 44.84 percent in 1990-95 and 1995-2000 respectively. Further, ERP reduced from 23.27 percent and 10.26 percent in the period of 2000-06 and 2006-12. The lowering of tariff rates was accompanied by a substantial relaxation of quantitative restrictions on imports. The non-tariff barrier (NTB) coverage declined significantly in most of the industrial group. Large reduction in rate of tariff and removal of quantitative restrictions on imports, Indian manufacturing sector access imported inputs at cheaper rate.

Figure 3.2: Rate of change in effective rate of protection over the period of 1975-76 to 2011-12



Sources: Deb (2003) and Author’s calculation.

The effective rate of protection (ERP) based on Corden's formula is the percentage excess of domestic value-added, vis-à-vis world value-added, introduced because of tariff and other trade barriers.

$$ERP_j = \frac{VA_j^{*} - VA_j}{VA_j} \quad \text{Equation (47)}$$

Where ERP_j is the effective rate of protection of j industry. VA_j* = value-added of the domestic final product j at free trade prices and VA_j = value added of the final product j in the absence of domestic tariffs.

This measures the distortion introduced due to tariff on the input prices as well as the final output prices, and therefore measures protection to domestic factors of production. The incentive structure of the domestic production process is described by the return to primary factors of production and the measure of protection based on value added is able to capture it.

Given the assumption, (1) the coefficients of physical input in the production of j is fixed and (2) the home price is equal to the international price plus tariffs, i.e. there are no tariff redundancies or non- tariff barriers. The assumption of the domestic price being equal to border price plus tariffs usually does not hold for countries like India, which have extensive non-tariff barriers (Goldar and Hasheem, 1994). We can define VA_j and VA_j^* as follows

$$VA_j = (1 - \sum a_{ij}) \qquad \text{Equation (48)}$$

$$VA_j^* = (1 + t_j) - \sum(1 + a_{ij}) \qquad \text{Equation (49)}$$

If (48) and (49) are substituted into (47) and rearranged we can write:

$$ERP_j = \frac{T_j - \sum a_{ij} T_i}{(1 - \sum a_{ij})} \qquad \text{Equation (50)}$$

Where ERP_j is the effective rate of protection of the j'th product, T_j is the nominal tariff rate for j'th product, T_i (i=1,2,…n) are the nominal tariff rates of the tradeable intermediate inputs used in the j'th activity. a_{ij} (i=1,2,…n) are the cost shares of inputs in total value of production of the j^{th} activity. The cost shares are computed after valuing output and tradeable inputs at world prices. The data on costs of production are obtained from the input-output tables.[11] $\sum a_{ij}$ is the sum of the shares of intermediate inputs (i ….. n) in the final value of j.

[11] It was not possible to use the cost data for the three-digit industries, as detailed data were not available for all the years of the study. A mapping was established between the I-O sectors and ASI sectors, so as to enable the I-O coefficients to substitute for the input costs of the industries. Use has been made of 115 sector I-O tables (2002-03 and 2006-07) for the years 2000-01 to 2005-06, and 2006-07 to 2011-12 respectively. This implicitly involves the assumptions that input output coefficients remained the same during the period under study.

There are two ways of obtaining the free-trade input coefficients. First is to assume that a developed country (like USA, which has low levels of nominal tariffs) input coefficients could approximate the world input-output coefficient. The second is to assume that free trade prices are equal to the protected prices deflated by appropriate tariff rates. This gives the free trade coefficients as

$$a_{ij} = \frac{P_{ij}}{P_j)} = \frac{P_{ij^*}/(1-T_i)}{P_{j^*}/(1-T_j)}$$ Equation (51)

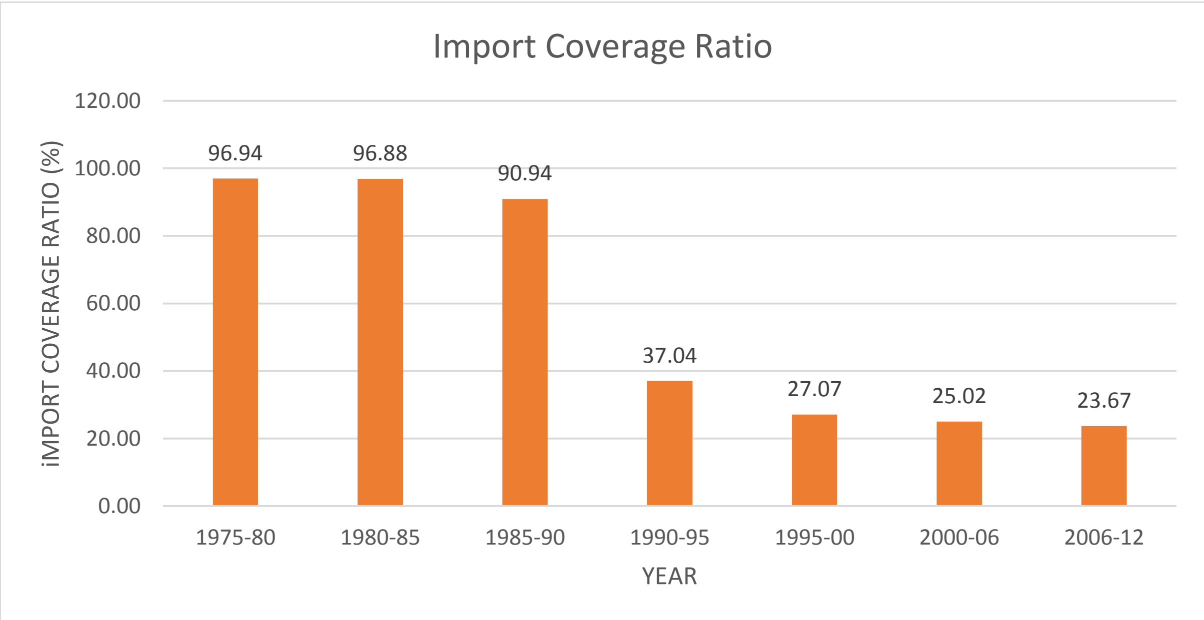
$$a_{ji} = a_{ji}^* \left[\frac{(1-T_j)}{(1-T_i)} \right]$$ Equation (52)

Import Coverage Ratio

Non-Tariff barriers (NTBs) dominate the trade regimes of most developing countries, governments in developing countries prefer non-tariff barriers to tariffs. In the word of Movchan and Eremenko (2003), "NTB are measures, other than tariffs, that are tightly connected with administrative activity and influence prices, quantity, structure and/or direction of international flows of goods and services as well as resources used to produce these goods and services" (Das, 2003). NTBs comprises all barriers to trade that are not tariffs. It also includes well-known trade distorting policies such as import quotas and voluntary export restraints. The measures range from narrowly conceived ones affecting particular products, industries and countries to more general ones that are rooted in national, institutions and policies. Thus it may be difficult to devise accurate quantification of many of these NTB measures.

Some of the barriers may be formal and are explicitly stated in official and governmental mandates. It is important to mention that there is no single useful way of measuring the "size" of an NTB. NTBs require several parameters to characterize them fully. In this connection it is important to know the various characteristics of NTBs, even though that it may be difficult to capture them empirically[12]. In order to quantify the particular occurrence of an NTB, it is important to look at the specific details of the implementation of that NTB. The specific details encompass direct information, which needs to be converted into useful form that can be understood and compared to other forms of trade interventions. There are however serious disadvantages to this direct approach especially as one is looking for a broad measure of NTBs. Even though direct information about NTBs is likely to be very accurate, it does not necessarily provide for a good starting point for a general analysis. Figure 3.3 show the rate of change in import coverage ratio over the period of 1975-76 to 2011-12. Non-tariff barriers operating through the import licensing system have long been the principal means of regulating imports and protecting domestic industries. The non-tariff barrier (NTB) coverage declined significantly in most of the industrial group. Trade reform initiated in 1991, prior to this, import coverage ratio is about 95 percent from 1975-76 to 1990-91. The ratio were reduced considerably in 1990s and 2000s. Import coverage ratio were reduced from 91 percent in 1985-90 to 37 percent and 27 percent in 1990-95 and 1995-2000 respectively. Further, ICR reduced from 25 percent and 23 percent in the period of 2000-06 and 2006-12.

Figure 3.3: Rate of change in import coverage ratio over the period of 1975-76 to 2011-12



Source: Deb Kusum Das (2003) and author's calculation.

[12] (1) reduction in the quantity of imports, (2) the increase in price of imports, (3) the change in the elasticity of demand for imports, (4) the variability of NTBs, (5) the uncertainty of imports, (6) welfare costs and (7) resource costs of NTBs. (See Das, 2003 and 2005).

One of the main questions in study of the NTB is a methodology of their measurement. The problems exist because of non-transparency of the NTB, their diversity, and difference in influences. There are several types of non-tariff barriers measurement[13]: frequency measures, price-change measures, quantity-impact measures, nominal rates of assistance, and indices deflators.

1. Frequency Measures: There are two common types of frequency measures: frequency ratio and import coverage ratio. Both of them are based on calculation of ratio of commodity lines subject to at least one NTB in total number of lines for the respective group of trade classification. For import coverage ratio, the value of imports of commodities subject to at least one NTB is used as a weight instead of number of categories. That allows introduce time factor in the measurement of NTB, as well as better evaluate importance of particular NTB for the trade as a whole.
2. Price-Change Measures: Measures based on evaluation of changes in price due to introduction of the NTB are the most useful. Alternative to other measures, they allow direct comparison between influence of tariff and non-tariff trade barriers. Moreover, these measures are deeply rooted in international trade theory that formulates an influence of trade restrictions in terms of price and quantity changes. The most known type of price-change measures is tariff equivalent that is calculated as growth in commodity price before and after use of the NTB (Deardorff & Stern, 1997).
3. Quantity-Impact Measures: Quantity-impact measures based upon econometric estimates of models of trade flows; and
4. Nominal Rate of Assistant: It is distinguished two types of rates of assistance: nominal rate of assistance and effective rate of assistance. Nominal rate of assistance is based on calculation of an increase in the gross returns from production due to existence of protective measures, including the NTB.

The import coverage ratio is defined as:

$$ICR_j = \frac{\sum D_i M_i}{\sum M_i} \qquad \text{Equation (53)}$$

[13] Movchan and Eremenko (2003) discuss these four measures along with specific NTB method.

Where Di is as usual a dummy variable defined as:

Di = 1, if the product is listed under R [banned/restricted, limited permissible, canalized
= 0, if the product is listed under F (OGL list).

j stands for a particular industry and i represents a product line within that particular industry. D_i is a dummy variable, Each product category (4-digit HS codes) is given either a number 1 or 0 depending whether the product is affected by a NTB or not. We made the following simplifications, items were treated as affected by NTB if they fall under the category: restricted (R). R covers all of the restrictive lists (banned/restricted, limited permissible and canalized) and hence given a weight of 1. The items under OGL were treated as free (F) and consequently given a weight of 0. M_i is the value of imports of the i^{th} product category which is subject to NTBs and $\sum M_i$ is the sum of the value of imports of all the product lines within the industry.

Import Penetration Ratio

This measure is used to examine the joint impact of reduction in both tariff and non-tariff barriers on the flow of imports and hence can be used as a proxy to measure the overall level of trade liberalization. The rationale is that reduction in both tariff and non-tariff barriers should lead to as an increase in import.

In the trade regime of India, where both QRs and tariffs played a dominant role, it is important to assess the combined impact of changes in both constituents of trade policy. Lowering of tariffs combined with shifting of products from restricted list to OGL should lead to an increase in the imports. The opposite results from a hike in tariffs and reverse shift in quantitative restrictions. We calculate the import penetration rate for three-digit industry as the ratio of industry imports to domestic availability. Domestic availability is defined as production plus imports minus exports. Aggregating the exports and imports of the product lines situated within a particular industry, we arrive at industry exports and imports.

$$IPR_j = \frac{M_J}{P_J + M_J - X_J} \qquad \text{Equation (54)}$$

j stands for the industry. P, M and X represent production, imports and exports.

Real Effective Exchange Rate

Nominal exchange rate is defined as the relative price of domestic currency in terms of foreign currency. The real effective exchange rate (REER) is usually defined as the nominal exchange rate adjusted by domestic local-currency prices relative to foreign local-currency prices. It is "real" because it adjusts for the relative inflation rates in the domestic economy and foreign economies. It is "effective" because it is constructed as a weighted average of the exchange rates relative to the countries trading partners. The weights are based on trade flows in the base year.

The REER is a proxy for a countries degree of competitiveness in world markets. An appreciation in REER results in a fall in the country's competitiveness, while a depreciation in REER leads to an increase in competitiveness.

The REER used for the regression analysis in this study is the one constructed and published by the Reserve Bank of India. It is based on the rupee's value against currencies of 36 countries. It is based on trade weights.

The formula used for the computation of REER may be written as:

$$REER = \prod_{i=1}^{n} \left[\left(\frac{e}{ei} \right) \left(\frac{P}{Pi} \right) \right]^{wi} ,$$

Equation (55)

where

e= exchange rate of rupee against a numeraire (SDRs) in index form (1985=100);

ei= exchange rate of currency i against the numeraire (SDRs) in index form (1985=100);

e/ei= exchange rate of rupee against currency i in an index form (1985=100);

P= India's wholesale price index (1985=100);

Pi= Consumer price index of country i (1985=100);

wi= weight attached to country/currency i in the index [∑∑wi =1]; and

n= number of countries/currencies in the index other than India.

The index constructed by the RBI is based on exchange rates *vis-à-vis* 36 countries. The weights wi are computed as wi= Xi/[∑Xi], where Xi is India's bilateral trade (export plus imports) with country i in the base period. An export-weight-based index is also computed by the RBI, for which the weights are worked out on the basis of India's exports to each of the 36 countries in the base period.

3.4. Basic Panel Regression Analysis

A panel regression analysis has been applied to study the effect of liberalization on industrial productivity. The term panel data refers to data sets where we have data on the same individual over several periods of time. The main advantage with having panel data as compared to a single cross-section or series of cross-sections with non-overlapping cross-section units is that it allows us to test and relax the assumptions that are implicit in cross-sectional analysis.

The analysis is based on pooled cross-section and time-series data. Growth rates of TFP computed for different years for the 22 two-digit industries are pooled. By combining time series of cross-sectional observations, panel data gives more informative data, more variability, less collinearity among variables, more degrees of freedom and more efficiency. Panel data can better detect and measure effects that cannot be observed in pure cross-sectional or time series data. By studying the repeated cross section of observations, panel data are better suited to study the dynamics of change. Panel regression runs for the entire period from 1975-76 to 2011-12. Further, to check the role of exchange rate on productivity, the whole period is divided into two time slots, i.e.

(i) Pre-liberalization period (1975-76 to 1990-91)
(ii) Post-liberalization period (1991-92 to 2011-12)

The multiple regression equation is specified as:

$$TFPG_{it} = F(Y/N_{it}, CR_{it}, K/L_{it}, NP_{it}, W_{it}, ERP_{it}, ICR_{it}, IPR_{it}, REER_{t}, u_{it})$$

where i denotes the ith industry and t = time period. Total number of Indian industries = 22
Y/N_{it} is output per factory is taken as a measure of firm size.
CR_{it} is concentration ration of a particular industry group captures the effect of market structure on TFPG.

K/L_{it} is the capital-labour ratio serves as technological variable.

NP_{it} is the non-production employee per production worker is also a technological variable and is related to the composition of work force.

W_{it} is the real wage rate

ERP_{it} is the effective rate of protection

ICR_{it} is the import coverage ration

IPR_{it} is the Import Penetration Ratio

$REER_{it}$ is the Real Effective Exchange Rate

Present study using fixed effect model as well as random effect model to run the panel regression model.

- A fixed effects model is a statistical model that represents the observed quantities in terms of explanatory variables that are treated as if the quantities were non-random. This is in contrast to random effects models and mixed models in which either all or some of the explanatory variables are treated as if they arise from random causes. In panel data analysis, the term fixed effects estimator is used to refer to an estimator for the coefficients in the regression model. If we assume fixed effects, we impose time independent effects for each entity that are possibly correlated with the regressors.

- A random effect model, also called a variance components model, is a kind of hierarchical linear model. It assumes that the dataset being analysed consists of a hierarchy of different populations whose differences relate to that hierarchy. In econometrics, random effects models are used in the analysis of hierarchical or panel data when one assumes no fixed effects. The random effects model is a special case of the fixed effects model.

Hausman test will be apply to decide fixed effect model is appropriate or random effect model is appropriate. The null hypothesis underlying the Hausman test is that the FEM and REM estimators do not differ substantially. The test statistic developed by Hausman has an asymptotic $\chi 2$ distribution. If the null hypothesis is rejected, the conclusion is that REM is not appropriate and that we may be better off using FEM, in which case statistical inferences will be conditional on the u_i in the sample.

3.5 Data Sources:

The importance of the data base in an empirical study like the present one needs hardly be emphasized. The longer the time series the greater the problem encountered in ensuring consistency of the data over time and consistency of the different series with each other.

Output per Factory:

The data of Output per factory and Number of factories used in this study is taken from the Annual Survey of Industries (ASI).

Real Wages to Worker

Data on Consumer Price Index for Industrial Workers has been noted down from Labour Bureau, Government of India and the data on wages to worker are available on the ASI.

Whole Sale Price:

The wholesale price series of before 1980 has been taken for study from a book by H.L. Chandhok. The data after 1981 is taken from the Office of the Economic Advisor, Government of India, Ministry of Commerce & Industry and the Department of Industrial Policy & Promotion (DIPP). All the data has been converted from various base years to the base year of 2004-05.

IPR

For the construction of the time series of import penetration ratio, exports and imports of manufactures (in Rs.) has been taken from Economic and Political Weekly Research Foundation, Goldar (2001). I got the data at disaggregate level and therefore made some adjustments see appendix 3.5 for details.

The value of gross output of organized manufacturing has been taken from the ASI. Import penetration ratio has been computed as the ratio of imports to (output + imports – exports).

REER:

The real effective exchange rate (REER) has been taken from a publication of the Reserve Bank of India (Handbook of Statistics on Indian Economy) and it is also available on www.rbi.org. The index is based on 36 country's bilateral trade weights, base 2005=100.

Capital-Labour Ratio:

To construct the time series on capital-labour ratio we required data on net fixed capital stock and the number of labour. The ASI provided useful time series data on these variables.

NPWPE:

The present study required data about total person engaged in manufacturing process, number of workers and non- production employees. To calculate the time series data on non-production employees, simply subtract number of workers from total person engaged. The ASI provided data on total person engaged and number of workers.

CR:

Output data of 22 manufacturing industries is taken for computation from the Annual Survey of Industry. Output data is deflated by suitable deflated and real output data used to calculate concentration ratio.

ICR:

Das (2003) has calculated import coverage ratio for various 3-digit manufacturing industries for the years 1980-85, 1986-90, 1991-95 and 1996-00. Present study adopts that data for empirical analysis. For the period of 1975-76 to 1979-80 and 2001-02 to 2011-2011, we extrapolate the series, see Appendix 3.6 for the details.

Das (2003) presented estimates of the effective rate of protection for various 3-digit manufacturing industries for the years 1980-85, 1986-90, 1991-95 and 1996-00. To get a complete series on ERP for the period 1975-76 to 2011-12, this study constructed ERP for the period of 2001-02 to 2011-12 and for the period of 1975-76 to 1979-80 we extrapolate the series. Then after we calculate ERP for 22 2-digit manufacturing industry see appendix 3.7 for mapping between from 3-digit to 2 digit ERP.

The industry wise ERP's are calculated by mapping the different tariff codes with the 3-digit ASI industries. The tariff rates for various product categories (items in the tariff working-schedule under HS codes) have been derived from the Customs Tariff Working Schedule. For each product category, the effective rate of duty was arrived at, taking into account quantifiable exemptions and was restricted to both ASI and auxiliary duties. The customs tariff working-schedule was not available for some years of the study and hence the same information was collected from http://www.eximkey.com/Sec/Customs/ID.