Modelling cost function approach under panel data framework to estimate total factor productivity growth for the Indian manufacturing industries

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MODELLING COST FUNCTION APPROACH UNDER PANEL DATA FRAME WORK TO ESTIMATE TOTAL FACTOR PRODUCTIVITY GROWTH FOR THE INDIAN MANUFACTURING INDUSTRIES

1. INTRODUCTION

Productivity is a key element in economic growth and development and productivity growth is known as a fundamental feature of economic development. Estimation of productivity useful in assessing the performance of the various industries over a period of time. The prosperity of developing nations has been attributed mainly to the sustained growth of their total factor productivity. Low total factor productivity growth (TFPG) or its negative trend is a commonly observed feature in most of the developing economies. After economic liberalization in India, the industrial development program mainly depends upon pulling the TFPG out of such grim state, though, the administration issues of TFPG are yet to draw sufficient consideration.

The modern example of TFPG isn't expansive based, as a few industries have contributed adversely to aggregate productivity. While the assembling area didn't see noteworthy efficiency gains in most piece of the 1990s, it saw some restoration in the ongoing years during which the general significance of administrations as a significant supporter of total TFPG has declined. The basic change in India includes the retention of laborers moving out of agriculture in the development segment—a segment that has seen considerable deceleration in profitability development—while work creation in quickly developing administrations has been moderate and in the assembling area rather stale. This makes India a one of a kind spots in the example of auxiliary change, when contrasted with a few of the present propelled economies. The undeniable inquiry is whether India can continue quicker development in the more drawn out run on the off chance that it doesn't concentrate on building up a strong assembling area.

India moved from a development pace of 3.5 percent per annum during 1950/51 to 1979/80 to a development pace of about 5.5 percent per annum during the 1980s due to steady exchange and mechanical progression and perhaps financial extension. Following the BOP emergency of 1990-1991, India embraced a profound and wide running advancement of local and outer arrangements. Be that as it may, the development rate scarcely moved from the 5.5-5.8 percent extend, during the 1990s [Virmani (2004, 2005a 2006b)]. Numerous investigators highlighted this riddle: How could the restricted changes of the 1980s raise the development pace of the Indian economy by 2 percent focuses, while the moderately significant changes of the 1990s had for all intents and purposes no quantifiable impact on the development pattern.

This has been reflected in assembling, with an extreme discussion on the impacts of financial changes on profitability development in Indian sorted out assembling. A lion's share of the investigations has discovered that profitability development in post changes time of 1990s decelerated from development rates found during the 1980s. This has confused financial specialists and strategy investigators, as the changes procedure was relied upon to quicken profitability development. A few examinations have attempted to give a clarification to this surprising result of the changes procedure.

A couple of studies, rather than straightforwardly censuring the changes for the log jam, have considered decaying limit usage liable for the marvels. They contended that inferable from flood in speculation exercises and imports in the post changes period, unaccompanied by proportionate extension of interest, limit use continued declining in the assembling part, in this manner antagonistically influencing profitability development [Uchikawa (2001); Goldar and Kumari (2003)]. Goldar and Kumari (2003) in their examination give various confirmations of breaking down limit use during the 1990s. One bit of confirmations they give identifies with the upward bounce in the proportion of gross fixed capital development to net worth included (at 1993/94 costs) in the sorted out assembling during the 1990s. As indicated by them, the proportion was just 44 percent during 1985-86 to 1989/90 yet contacted as high as 76 percent during 1995/96 to 1997/98. The circumstance turned out to be more terrible from 1997 through 2001. The proportion of gross capital stock to net estimation of yield (at 1993-94 costs) expanded from a normal of 78.6 percent between 1992/93 and 1997/98 to 83.7 percent between 1998/99 and 2001-02. It, in any case, declined pointedly to 61.2 percent during 2002/03 to 2007/08. Along these lines, a right correlation of efficiency development somewhere in the range of 1980s and 1990s can be made just if the profitability development is estimated net of limit usage. Curiously, much subsequent to changing for limit usage, Goldar and Kumari (2003) found that profitability development in 1990s remained at almost a similar level as during 1980s. Be that as it may, the inquiry to answer stayed with regards to why changes neglected to quicken the profitability development in the Indian assembling. In accordance with Athukorala and Rajapatirana (2000), they contended that such positive efficiency upgrading impacts of monetary changes might be showed with a delay and henceforth expected an improvement in profitability development in the years to come. Be that as it may, this doesn't clarify a decrease in efficiency during the change's procedure.

The New Industrial Policy (NIP) presented in mid-1991 being outward-situated annulled permitting of capital goods, decreased number of businesses in public sector, expanded remote possessions in domestic industries, presented deregulation in little scope modern units, diminished trade obstructions and prompted private speculation framework. Those components of economic reform program alongside others were introduced to enhance productivity and efficiency in Indian industries. The competition and new technologies generally enhance the productivity and reduce the production costs of industries with comparative advantages.

While there is a developing volume of literature undertaking an explicit examination of reform processes, the impact of economic reforms on productivity of Indian industries remained a matter of significant discussion. The traditional industry argument maintains that the removal of protection may result in large number of industries becoming bankrupt. Alternatively, advocates of liberalization claim that the effect should be marginal, as only the inefficient industries exit, providing opportunities to the remaining industries to improve their performance.

In this backdrop, the aim of the study is to examine the Total Factor Productivity Growth (TFPG) of top ten major Indian manufacturing industries through the cost function approach. We have chosen the industries on the basis of their share in the Gross Manufacturing Value Added. The industries, that are considered in our study are Manufacture of Food Products and Beverages, Manufacture of Textiles, Manufacture of Coke, Refined Petroleum Products and Nuclear Fuel, Manufacture of Chemicals and Chemical Products, Manufacture of Rubber and Plastic Products, Manufacture of Other Non-Metallic Mineral Products, Manufacture of Basic Metals, Manufacture of Machinery and Equipment N.E.C, Manufacture of Motor Vehicles, Trailers and Semi-Trailers. The remaining manufacturing industries were put together in a category called 'Others'. Our selected nine industries contribute 65.79%, the remaining 34.21% in 'Others' in the total value added of the manufacturing sector in India. In this regard, we have used panel data econometric approach, namely, Fixed Effect Model and Random Effect Model to estimate the trans-log cost function so that it gives more consistent parameters and allows us to get rid from the problems of serial correlation, endogeneity, measurement error, omitted variable bias and also permit us to see the heterogeneity in long-run parameters. This particular methodological approach to estimate TFPG for Indian manufacturing industries is least explored till the time. Now, the time period considered for our study is 1980-81 to 2016-17. An estimation of TFPG with the help of the trans-log cost function approach comes out from the interaction between economies of scale and technical change. In this case, technical progress is viewed as a downward shift in the production process where returns to scale is represented by the elasticity of cost with respect to output.

Productivity growth is connected to key parameters relating to the elasticity of cost with respect to output of a specific cost function. When the cost elasticities are known, the inter-temporal shifts in the cost function and scale effects can be isolated. We hope that, in this way TFP change of selected industries over the years could be measured and the sources of TFP growth is identified. Before proceeding further, we will briefly present the theoretical concept of total factor productivity.

1.1. Theoretical Framework

Productivity change occurs when the index of output and the index of input changes in different rates. But, here two questions arise: how productivity change can be measured? and what are the sources of measured productivity change?

For the former one, the econometric studies of productivity change utilized either a primal approach or a dual approach. The primal approach is based on direct estimation of production function and for the dual approach we have to estimate the cost function of profit function. Now for the latter, decomposition of the sources of total factor productivity growth has been answered by various experts in various manners.

Here, in general, TFP change is decomposed into two different parts related to the technical change, which is reflected by a parametric shift in cost function and the returns to scale.

The duality hypothesis stipulates that for every production, there exists a dual cost function relating to output and input prices. The dual cost function contains all the information that the production function contains. Binswanger (1974) has shown that the cost function is more desirable for econometric analysis than the production function for a variety of reasons. Shephard (1953), Uzawa (1964) favored the duality approach. For a firm, the cost function models the association between firm costs, output, and input prices. We may think that the use of a cost function rather than a production function for estimating TFPG has several advantages. There are sure purposes behind thinking about the cost work, which might be bulleted as underneath:

- According to the essential guideline of duality in production, the cost function sums up all the economically relevant data about the way toward changing inputs into output. Therefore, the evaluated cost function permits total depiction of innovation accessible to a production unit.

- ❖ The cost function permits estimation when output prices are inaccessible or are not decided in a serious market.
- ❖ The cost function permits a generally clear figuring of alternative cost indices for policy investigation.
- ❖ The cost function approach is relevant in so far as firms are minimizing costs. It doesn't require the state of benefit boost.
- ❖ Cost functions are homogeneous in prices regardless of the homogeneity properties of the production function, because a doubling of all price will double the costs but will not affect factor ratios.
- ❖ In the special case of the Trans-log cost function, to which the method is applied, problems of neutral or non-neutral efficiency differences among observational units or of neutral and non-neutral economies of scale can be handled conveniently. Therefore, these problems will not result in biased estimates of the production parameters. Most methods of estimating production cannot handle this problem properly.
- ❖ In production function estimation, high multi-collinearity among the input variables often causes problems. Since there is usually little multi-collinearity among factor prices, this problem does not arise in cost function estimation.

1.2. Brief Survey on Literature

There are numerous investigations dealings with the estimation of TFP and TFPG for the Indian manufacturing industries, and because of the various strategies utilized and various methodologies of variable development, there are clashing outcomes.

Thinking about the information for the Indian manufacturing industries, different examinations have indicated that the TFP growth has declined during the beginning stages of the 1980s. Be that as it may, in the beginning stages of the progression time frame, TFP growth improved because of exchange transparency, unwinding in the permitting arrangements, and so forth.

Though, there have been a limited number of studies on path breaking cost function estimation for Indian industries, but we have reviewed most of it. Murty (1986) has estimated a cost function for Indian manufacturing at an aggregate level using time series data for the period 1960-77. He has used a two-stage approach, estimating an energy and aggregate sub-model. In the energy sub-model, unit energy cost is taken as a function of the prices of coal, oil, and electricity. In the aggregate sub-model, the cost function is specified in terms of output and prices of labour, capital, materials, and energy. The price index of energy derived from the former is used in the latter. Price index for capital input is obtained by estimating the user cost of capital based on the price of investment goods, rate of return, and the rate of replacement of investment goods (following the work of Jorgenson and associates). Vashist's study (1984) is very similar to that of Murty's (1986). One important difference is that Vashist has not included materials input in the aggregate sub-model. Also, he has assumed constant returns to scale. And interesting feature of this study is the use of the Divisia price index for labour input. The price index for capital input has been formed by subtracting labour income from value added and then dividing the figure by real fixed capital stock. For estimating the cost function, Vashist has used time-series data for 1960-71. Jha, Murty and Paul (1991) have estimated trans-log cost function for four industries, namely cement; electricity and gas; cotton textiles; and iron and steel, using time-series data for the period 1960-1 to 1982-3. The model has been so specified as to allow for non-neutral technological change. Their results indicate that technological progress has been capital saving in the iron and steel and cement industries, labour and materials input (including energy) saving in cotton textiles, and biased towards saving both labour and capital in the electricity and gas industries. Jha et al. (1991) find the cost flexibility to be less than one, indicating economies of scale. Similar results have been reported by Goldar and Mukhopadhyay (1991).

The writing on estimation of TFP is very broad; which is talked about in the accompanying:

Das et al. (2010) have looks at the general commitments of factor aggregation and productivity growth in the various sector of the Indian economy.

As indicated by Kathuria et al. (2013), development in efficiency is the main conceivable course to expand way of life and in this way, it is considered as a proportion of government assistance i.e., welfare.

TFP and labour profitability have been concentrated by Harris and Moffat (2016) in the UK. The noteworthy decay post-2008 didn't recuperate before 2012. In this manner, they inferred that the decline in the productivity growth is probably going to be changeless as opposed to repetitive.

Kapelko et al. (2017) researched the effect on powerful efficiency development in the Spanish food fabricating industry. Negative effects on efficiency were found. In any case, assorted impacts are seen between various sub-businesses and firm-sizes.

Now, it would be useful to note here some limitations of the cost function studies for Indian industries. First, it is known that flexible functional forms, such as trans-log, do not satisfy the positivity and concavity conditions globally. It is therefore important to check whether the model is well-behaved in the sample region. This has, however, not been done in most studies, Secondly, the cost functions used for the analysis involve the assumptions of,(a) cost minimization and, (b) full equilibrium at all data points. Both the assumptions can be seriously questioned in the context of Indian industries. Thirdly, the models assume that the prices of inputs are exogenous and invariant to the input use decisions of the firms. This assumption is incorrect when the analysis is undertaken at the aggregate level. Fourthly, there are inadequacies in the price indices used for estimating the cost function.

In this backdrop, ***we have found that most of the studies have estimated the cost function and very few have estimated the TFPG from cost function approach***. **Again, majority of these study uses either cross-section or time series data**, such as, Goldar has used state-wise cross-sectional data for 1971, Kar and Chakraborty time-series data for seven energy intensive industries for 1959-71. **In the recent year, no significant work has been done using panel data**. **Thus, our study is an attempt to find out the Total Factor Productivity Growth for some selected manufacturing industries in India using cost function approach.**

Now the paper is organized as follows: Section 1.3 deals with the major objectives of our study, Section 2 depicts methodology & database. Total Factor Productivity Growth (TFPG) estimates are presented in section 3. In Section 4, we present concluding remarks and policy prescription.

1.3. Objectives of the study:

The major objectives of our study can be presented as:

1) To estimate the total factor productivity growth (TFPG) and its component for some selected manufacturing industries in India by using cost function approach over the year 1980-81 to 2016-17.

2) To estimate the annual average growth rate of output, factors of input and cost and also make a comparative analysis among the decades.

2. DATABASE AND METHODOLOGY:

So as to follow the changing effect of changes on productivity and output, the current investigation utilizes the information for wide assembling divisions from 1980-81 to 2016-17. To comprehend the expansive patterns in factors in pre and post changes period, the examination time frame has been isolated in two sub-periods (a) Period I (1980-81 to 1990-91), and (b) Period II (1991/92 to 2016-17). Taking into account the way that there has been wide varieties in productivity and output in post reform period as saw by Hashim et al (2009), Period II has been further sub-separated in three sub-period: (I) Sub-period 1 (1991-92 to 2001-02), Sub-period 2 (2002-03 to 2012-13) and Sub-period 3 (2013-14 to 2016-17).

Description of data: The present study is based on industry level time series data taken from: Several issues of Annual Survey of Industries (ASI), Economic Survey, Statistical Abstracts (several issues), RBI Handbook of statistics on Indian Economy published by Reserve Bank of India (RBI) covering a period of 37 years from 1980-81 to 2016-17. Under this long time period four industrial classifications were made

Classification of industries:

The classification of industries followed in ASI is based on the National Industrial Classification 1970 (NIC-1970). The switch to the NIC-1987 since 1973-74 to 1997-98, further switch to NIC-1998 from 1998-99 to 2003-04 and also switch to the NIC-2004 from 2004-05 to 2007-08 and thereafter, it was switched to NIC-2008 from 2008-09 till date. We have made the data comparable keeping in mind the composition of the selected manufacturing industries for several periods in our study. Though we have taken up 2-digit level in industries, but for making data comparable, we have gone on to the 3-digit level industries under the 2-digit level industries.

Description of variables:

- **Capital Stock and Price of Capital:**

The measurement of the capital is the most complex of all input measurement. Actually, there is no universally accepted method for the measurement of capital and as a result, several methods have been applied to estimate capital stock in several studies. In our study we have taken, the implicit deflator for fixed capital stock is done by the ratio of Gross Fixed Capital Formation (GFCF) at current and constant prices. Gross fixed capital formation is calculated by considering a single base year (1990-91). The base year is considered as 1990-91= 100. Rental price on capital is the price of capital (P_K) that is obtained from the ratio if interest paid to capital invested.

- **Labour and Price of Labour:**

Total number of persons engaged as measure of labour input includes both workers and persons other than workers.

Laborers are described to fuse all individuals utilized straightforwardly or through any association whether for pay or not and busy with any assembling procedure or in cleaning any bit of the device or premises utilized for collecting process or in some other kind of work circumstantial to or related with the amassing strategy or the subject of the gathering system.

And employees incorporate all labourers characterized above and people getting wages and holding administrative or administrative positions occupied with administrative office, store keeping area and government assistance segment, deals division as additionally those occupied with acquisition of crude materials and so on or acquisition of fixed resources for the factory and watch and ward staff.

Price of Labour (P_L) is the total emoluments divided by total number of persons engaged.

P_L= total emoluments / total number of persons engaged (L)

- **Measurement of Output:**

In our study, output is measured by real gross value added (GVA). To arrive at real value, we have deflated GVA by the ratio of GDP at current to constant prices GDP deflator. We measured GDP deflator by considering a single base year (1990-91). Gross output is not taken here as measure of output in order to avoid the possibility of double counting.

- **Total Cost:**

Total cost is the sum of the expenditure on variable inputs such as labour (L), capital (K) and energy (E).i.e.

$TC = P_L L + P_K K$

Where, P_L= price of labour, P_K= price of capital,

METHODOLOGY:

We estimate TFP by using cost function approach and decompose the TFP change in to two component parts: one part due to technical change and other returns to scale.

Technical change is reflected through shift in cost function. Returns to scale is represented by the cost/output elasticity. Productivity growth is connected to key parameters identifying with the elasticities of cost with respect to output of a specific cost function. When the cost elasticities are known, the inter-temporal shifts in the cost function and scale effects can be isolated.

The growth rate of TFP is defined as: $\dot{TFP}=\dot{Q}-\dot{F}$

Where, rate of change of output is$\dot{Q}$, $\dot{F}$ is rate of change of total factor inputs; it is the proportionate change in the variables over time. In other words, TFPG is the unexplained part of output growth which is not explained by the growth of inputs taken together.

Let us represent the cost function in three explanatory variables, by

$$C= F (Q, P_L, P_K, T) \text{ ---------------------(1)}$$

Where P_L is the price of labour, P_K is the price of capital, T the index of technology, which is a simple time function, and Q is the output.

The cost function specified in the study is the Trans-log form, which is more flexible, compared to the alternative functional forms and Trans-log specification of this generalised cost function as given in equation (1) is:

$$\ln C(Q,P_L,P_K,T)=\alpha_0+\alpha_Q\ln Q+\alpha_L\ln P_L+\alpha_K\ln P_K+\alpha_T\ln T+\beta_{QL}\ln Q.\ln P_L+\beta_{QK}\ln Q.\ln P_K+\beta_{QT}\ln Q.\ln T+\beta_{LK}\ln P_L.\ln P_K+\beta_{LT}\ln P_L.\ln T+\beta_{KT}\ln P_K.\ln T+0.5\gamma_Q(\ln Q)^2+0.5\gamma_L(\ln P_L)^2+0.5\gamma_K(\ln P_K)^2+0.5\gamma_T (\ln T)^2 \text{ --------------------------------(2)}$$

Now, differentiating (1) totally with respect to T, we get,

$$\dot{TFP} = -\dot{\theta}+ (1- \eta_{CQ})\, \dot{Q} \text{ -----------------------(3)}$$

In equation (3), the proportionate change in cost is the sum of proportionate change in aggregate inputs (the first term on the right side), the cost/output elasticity (a part of the second term) denoted by, η_{CQ}, and the proportionate shift in the cost function (the third term) due to technology denoted by, $\dot{\theta}$.

The cost share equations can be obtained from equation (1) using Shepherd's lemma as in equation (4).

$$S_i=\alpha_i+0.5\sum_j \beta_{ij} \ln P_j+\beta_{Qi}\ln Q+\gamma_i\ln T \text{------------(4)}$$

For i, j = Labour (L), Capital (K); Where S_i is the cost share.

The cost/output elasticity estimates are obtained from the parametric estimates of the model, derived from equation (1), as presented in equation (5).

$$\eta_{CQ}=\alpha_Q+\alpha_{QQ}\ln Q+\sum_i \beta_{Qi}\ln P_i+\gamma_Q \ln T \text{ --------(5)}$$

The cost/output elasticity η_{CQ} is computed for each year on condition that the parameters of the equation are stable over the years. The parameters of the trans-log cost function are estimated through general Panel estimation, Fixed Effect Model (FEM) and Random Effect Model (REM).

The presence of cross-section and period specific effects terms may be handled using fixed or random effects methods. With some restrictions, we may specify models containing effects in one or both dimension, for example, a fixed effect in the cross-section dimension, a random effect in the period dimension, or a fixed effect in the cross-section and a random effect in the period dimension. Note, in particular, however, that two-way random effects may only be estimated if the data are balanced so that every cross-section has the same set of observations.

Fixed Effects

The fixed effect model allows for heterogeneity or individuality among the individuals by allowing to have its own intercept value. Fixed effect is due to the fact that although the intercept may differ across the individuals, but intercept does not vary over time, i.e. it is time variant.

The fixed effects portions of specifications are handled using orthogonal projections. In the simple one-way fixed effect specifications and the balanced two-way fixed specification, these projections involve the familiar approach of removing cross-section or period specific means from the dependent variable and exogenous regressors, and then performing the specified regression using the demeaned data.

Note that if instrumental variables estimation is specified with fixed effects, EViews will automatically add to the instrument list, the constants implied by the fixed effects so that the orthogonal projection is also applied to the instrument list.

Random Effects

The random effects specifications assume that the corresponding effects, like, cross-section or period specific effects are realizations of independent random variables with mean zero and finite variance. Most importantly, the random effects specification assumes that the effect is uncorrelated with the idiosyncratic residual ε_{it}.

EViews handles the random effects models using feasible GLS techniques. The first step, estimation of the covariance matrix for the composite error formed by the effects and the residual (*e.g.*,$v_{it}=\delta_i+\gamma_t+\varepsilon_{it}$, in the two-way random effects specification), uses one of the quadratic unbiased estimators (QUE) from Swamy-Arora, Wallace-Hussain, or Wansbeek-Kapteyn.

Briefly, the three QUE methods use the expected values from quadratic forms in one or more sets of first-stage estimated residuals to compute moment estimates of the component variances (σ_δ^2,σ_γ^2, σ_ε^2). The methods differ only in the specifications estimated in evaluating the residuals, and the resulting forms of the moment equations and estimators. The Swamy-Arora estimator of the component variances, cited most often in textbooks, uses residuals from the within (fixed effect) and between (means) regressions. In contrast, the Wansbeek and Kapteyn estimator uses only residuals from the fixed effect (within) estimator, while the Wallace-Hussain estimator uses only OLS residuals. In general, the three should provide similar answers, especially in large samples. The Swamy-Arora estimator requires the calculation of an additional model, but has slightly simpler expressions for the component variance estimates. The remaining two may prove easier to estimate in some settings. Additional details on random effects models are provided in Baltagi (2005), Baltagi and Chang (1994), Wansbeek and Kapteyn (1989). Note that your component estimates may differ slightly from those obtained from other sources since EViews always uses the more complicated *unbiased* estimators involving traces of matrices that depend on the data (see Baltagi (2005) for discussion, especially "Note 3" on p. 28).

Once the component variances have been estimated, we form an estimator of the composite residual covariance, and then GLS transform the dependent and regressor data. If instrumental variables estimation is specified with random effects, EViews will GLS transform both the data and the instruments prior to estimation. This approach to random effects estimation has been termed generalized two-stage least squares (G2SLS).

After estimating these two models, we shall have to decide which model is appropriate to accept. To check it we must use to Hausman test.

Hausman Test for Correlated Random Effects

A central assumption in random effects estimation is the assumption that the random effects are uncorrelated with the explanatory variables. One common method for testing this assumption is to employ a Hausman (1978) test to compare the fixed and random effects estimates of coefficients (for discussion see, for example Wooldridge 2002, p. 288 and Baltagi 2005, p. 66). To perform the Hausman test, we have to consider the two hypotheses, where Null hypothesis (H_0): REM is appropriate and Alternative hypothesis (H_1): FEM is appropriate and you must first estimate a model with your random effects specification. EViews will automatically estimate the corresponding fixed effects specifications, compute the test statistics, and display the results and auxiliary equations.

3. Results &Discussion

In this section, we have presented the estimates of Total Factor Productivity (TFP) growth and its components using trans-log cost function approach for top ten manufacturing industries on the basis of its higher share in the Gross Manufacturing Value Added. In this regard, results from Panel FEM test, REM test and Hausman test are presented in Table-1, Table-2 and Table-3 respectively.

Table-1: RESULT FROM FIXED EFFECT MODEL

Dependent Variable: LNC Method: Panel Least Squares Date: 07/24/20
Time: 20:03 Sample: 1 37
Periods included: 37
Cross-sections included: 10
Total panel (balanced) observations: 370

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	19.84939	5.296206	3.747851	0.0002
LNPK	-1.109489	0.595192	-1.864086	0.0632
LNPK2	-0.122138	0.056944	-2.144866	0.0327
LNPK_LNT	0.100324	0.101440	0.988991	0.3234
LNPL	2.903386	0.856015	3.391748	0.0008
LNPL2	0.016947	0.055685	0.304328	0.7611
LNPL_LNPK	-0.065763	0.100922	-0.651618	0.5151
LNPL_LNT	0.323117	0.106956	3.021036	0.0027
LNQ	-1.455274	0.755861	-1.925321	0.0550
LNQ2	0.055190	0.028786	1.917225	0.0560
LNQ_LNPK	0.012216	0.001903	6.418413	0.0000
LNQ_LNPL	-0.228849	0.049012	-4.669229	0.0000
LNQ_LNT	0.098148	0.045518	2.156243	0.0318
LNT	-0.090919	0.729501	-0.124632	0.9009
LNT2	-0.162967	0.058228	-2.798769	0.0054

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.980268	Mean dependent var	12.93267
Adjusted R-squared	0.978957	S.D. dependent var	1.353562
S.E. of regression	0.196352	Akaike info criterion	-0.355154
Sum squared resid	13.33967	Schwarz criterion	-0.101305
Log likelihood	89.70349	Hannan-Quinn criter.	-0.254323
F-statistic	747.3615	Durbin-Watson stat	1.090408

Prob(F-statistic)	0.000000

Source: Author's own estimation using Eviews

Table-2: RESULT FROM RANDOM EFFECT MODEL

Dependent Variable: LNC
Method: Panel EGLS (Period random effects) Date: 07/24/20 Time: 20:17
Sample: 1 37
Periods included: 37
Cross-sections included: 10
Total panel (balanced) observations: 370
Swamy and Arora estimator of component variances

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	9.530601	4.350027	2.190929	0.0291
LNPK	-1.113554	0.745422	-1.493856	0.1361
LNPK2	-0.287180	0.070825	-4.054780	0.0001
LNPK_LNT	-0.007441	0.122624	-0.060680	0.9516
LNPL	1.639860	0.947553	1.730626	0.0844
LNPL2	-0.107123	0.065753	-1.629187	0.1042
LNPL_LNPK	0.078291	0.122209	0.640637	0.5222
LNPL_LNT	0.788915	0.127967	6.164976	0.0000
LNQ	-0.749325	0.522399	-1.434393	0.1523
LNQ2	0.042998	0.019879	2.163031	0.0312
LNQ_LNPK	0.006278	0.001128	5.564686	0.0000
LNQ_LNPL	-0.280199	0.047293	-5.924683	0.0000
LNQ_LNT	0.167233	0.051282	3.261047	0.0012
LNT	-0.155134	0.839983	-0.184687	0.8536
LNT2	-0.141580	0.066172	-2.139584	0.0331

Effects Specification

	S.D.	Rho
Period random	0.000000	0.0000
Idiosyncratic random	0.250225	1.0000

Weighted Statistics

R-squared	0.948641	Mean dependent var	12.93267
Adjusted R-squared	0.946615	S.D. dependent var	1.353562
S.E. of regression	0.312742	Sum squared resid	34.72162
F-statistic	468.3652	Durbin-Watson stat	0.657938
Prob(F-statistic)	0.000000		

Unweighted Statistics			
R-squared	0.948641	Mean dependent var	12.93267
Sum squared resid	34.72162	Durbin-Watson stat	0.657938

Source: Author's own estimation using Eviews

After estimating FEM and REM, we shall have to decide which model is good to accept. To check it we must use to Hausman test.

Table-3: RESULT FROM HAUSMAN TEST FOR CORRELATED RANDOM EFFECTS

Correlated Random Effects - Hausman Test Equation: Untitled
Test period random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Period random	225.692472	12	0.0000

** WARNING: estimated period random effects variance is zero. Period random effects test

comparisons:

Variable	Fixed	Random	Var(Diff.)	Prob.
LNPK LNPK2	-1.083889	-1.113554	0.053769	0.8982
LNPK_LNT LNPL	-0.180957	-0.287180	0.000654	0.0000
LNPL2 LNPL_LNPK	0.220013	-0.007441	0.001359	0.0000
LNPL_LNT LNQ	2.787434	1.639860	0.101962	0.0003
LNQ2 LNQ_LNPK	-0.115132	-0.107123	0.000785	0.7750
LNQ_LNPL	-0.101924	0.078291	0.001352	0.0000
LNQ_LNT	0.516042	0.788915	0.004004	0.0000
	-0.825180	-0.749325	0.007673	0.3865
	0.043771	0.042998	0.000011	0.8149
	0.007510	0.006278	0.000000	0.0000
	-0.351924	-0.280199	0.000121	0.0000
	0.180157	0.167233	0.000097	0.1891

Period random effects test equation:
Dependent Variable: LNC Method: Panel Least Squares Date:
07/24/20 Time: 20:32 Sample: 1 37
Periods included: 37
Cross-sections included: 10
Total panel (balanced) observations: 370
WARNING: estimated coefficient covariance matrix is of reduced rank

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C LNPK	9.619055	4.134676	2.326435	0.0206
LNPK2	-1.083889	0.780656	-1.388433	0.1660
LNPK_LNT LNPL	-0.180957	0.075298	-2.403208	0.0168
LNPL2 LNPL_LNPK	0.220013	0.128046	1.718228	0.0867
LNPL_LNT LNQ	2.787434	0.999909	2.787686	0.0056
LNQ2 LNQ_LNPK	-0.115132	0.071473	-1.610849	0.1082
LNQ_LNPL	-0.101924	0.127619	-0.798661	0.4251
LNQ_LNT LNT	0.516042	0.142757	3.614818	0.0003
LNT2	-0.825180	0.529692	-1.557849	0.1203
	0.043771	0.020151	2.172173	0.0306
	0.007510	0.001134	6.620350	0.0000
	-0.351924	0.048559	-7.247412	0.0000
	0.180157	0.052218	3.450109	0.0006
	NA NA	NA NA	NA NA	NA NA

Effects Specification

Period fixed (dummy variables)

R-squared Adjusted R-squared S.E. of regression Sum squared resid Log likelihood F-statistic Prob(F-statistic)	0.970271 0.965825 0.250225 20.09866 13.86992 218.2589 0.000000	Mean dependent var S.D. dependent var Akaike info criterion Schwarz criterion Hannan-Quinn criter. Durbin- Watson stat	12.93267 1.353562 0.189892 0.708167 0.395755 0.952274

Source: Author's own estimation using Eviews

From Table-3, we get a statistically significant P-value (<5%), so we can reject the null hypothesis and accept alternative hypothesis. Which implies that Fixed effect model is most appropriate model. Therefore, from the above FEM result (Table-1), we can formulate the trans-log cost function as in equation-6,

$$LnC=19.84939 - 1.109489\, LnP_K - 0.122138\, (LnP_K)^2\, 0.100324\, LnP_KLnT + 2.903386\, LnP_L + 0.016947\, (LnP_L)^2 - 0.065763\, LnP_LLnP_K + 0.323117\, LnP_LLnT -1.455274\, LnQ + 0.055190\, (LnQ)^2 + 0.012216\, LnQLnP_K - 0.228849\, LnQLnP_L + 0.098148\, LnQ\, LnT - 0.090919\, LnT -0.162967\, (LnT)^2 \text{-------------------------------------}(6)$$

By using the above Trans-log equation, now we can estimate the Total Factor Productivity Growth (TFPG) for each and overall manufacturing industry. The results can be presented as in the following.

Manufacture of Machinery and Equipments:

Machinery and equipment industry act autonomously on materials either precisely or thermally or perform procedure on materials, (for example, dealing with, splashing, gauging or pressing), including their mechanical segments that deliver and apply power, and any uncommonly made essential parts. This incorporates the production of fixed and portable or hand-held gadgets, whether or not they are intended for mechanical, building and structural designing, horticultural or home use. In this paper, we found that, TFPG is declining in the soon after advancement time frame (pre-reform), at that point it increments, 0.0711%. Be that as it may, in the last sub-time frame there was an exceptional fall than the other decade. The underlying bounce in profitability is because of the expanded access to innovation and compelling utilization of benefits emerging from proceeded with assurance. In this way TFPG has declined with a decrease in compelling insurance to nonpartisan levels.

Table-4: TFPG of Manufacture of Machinery and Equipments

PRE-REFOM PERIOD (1980-81 TO 1990-91)		POST-REFOM PERIOD (1991-92 TO 2016-17)					
YEAR	TFPG	YEAR	TFPG	YEAR	TFPG	YEAR	TFPG
1980-81	-0.0278	**1991-92**	0.0809	**2002-03**	-0.0560	**2013-14**	-0.1917
1981-82	0.1240	**1992-93**	0.0762	**2003-04**	0.0733	**2014-15**	0.0955
1982-83	0.1147	**1993-94**	0.0453	**2004-05**	0.1119	**2015-16**	0.0033
1983-84	0.1068	**1994-95**	0.0711	**2005-06**	0.1290	**2016-17**	0.0010
1984-85	0.1017	**1995-96**	0.2406	**2006-07**	0.1072		
1985-86	0.0675	**1996-97**	0.0054	**2007-08**	0.1199		
1986-87	0.0032	**1997-98**	-0.0910	**2008-09**	0.1769		
1987-88	0.0840	**1998-99**	0.1025	**2009-10**	-0.0324		
1988-89	0.0319	**1999-2000**	-0.0346	**2010-11**	0.0293		
1989-90	0.1265	**2000-01**	-0.0375	**2011-12**	0.1076		
1990-91	0.0761	**2001-02**	-0.0305	**2012-13**	0.0157		
ANNUAL AVERAGE	0.0735		0.0389		0.0711		-0.0230

Source: Author's own estimation

Manufacture of Other Non-Metallic Mineral Products Industry:

As indicated by ASI, this division incorporates producing exercises identified with a solitary substance of mineral starting point. This division incorporates the assembling of glass and glass items (for example level glass, empty glass, strands, specialized china and so on.), fired items, tiles and heated mud items, and concrete and mortar, from crude materials to completed articles. The assembling of formed and completed stone and other mineral items is likewise remembered for this division. For that industry complete factor efficiency development is additionally declined in the first sub-time of the post-change period, at that point expanding and again extraordinary fall in TFPG is happened. A few ventures in this sub-area produce profoundly work concentrated items in the Small-scale part (SSI), in which the innovation hole with capital escalated creation procedures might not have made a difference.

Table-5 TFPG of Manufacture of Other Non-Metallic Mineral Products Industry

PRE-REFOM PERIOD (1980-81 TO 1990-91)		POST-REFOM PERIOD (1991-92 TO 2016-17)					
YEAR	TFPG	YEAR	TFPG	YEAR	TFPG	YEAR	TFPG
1980-81	0.2451	**1991-92**	0.1937	**2002-03**	-0.0225	**2013-14**	-0.0691
1981-82	0.2554	**1992-93**	-0.0519	**2003-04**	0.0120	**2014-15**	0.0548
1982-83	0.3606	**1993-94**	0.0391	**2004-05**	0.1915	**2015-16**	-0.0784
1983-84	0.1688	**1994-95**	0.1079	**2005-06**	-0.0095	**2016-17**	0.0994
1984-85	0.1689	**1995-96**	0.2012	**2006-07**	0.2513		
1985-86	0.1295	**1996-97**	-0.0686	**2007-08**	0.1841		
1986-87	0.0280	**1997-98**	0.0792	**2008-09**	0.0455		
1987-88	0.1282	**1998-99**	-0.0324	**2009-10**	0.0223		
1988-89	0.0751	**1999-2000**	0.1742	**2010-11**	-0.0871		
1989-90	0.1322	**2000-01**	0.0009	**2011-12**	0.1027		
1990-91	0.1524	**2001-02**	0.0066	**2012-13**	-0.0161		
ANNUAL AVERAGE	0.1677		0.0591		0.0613		0.0017

Source: Author's own estimation

Manufacture of Textiles

This industry incorporates planning and turning of textile fibres just as textile weaving, completing of textiles and wearing attire, production of made-up textile articles. Toward the end of the 1980s, textile industry was probably the most elevated investor in made fares. The majority of these fares were anyway of Cotton materials shopper items. The remainder of materials industry especially that dependent on man-made strands and engineered material was profoundly secured and wasteful. The position was comparative in woollen, silk and different materials and somewhat in cotton yarn and different intermediates. In this way, complete factor profitability development for materials segment as a declining pattern from pre to post change period.

Table-6: TFPG of Manufacture of Textiles

PRE-REFOM PERIOD (1980-81 TO 1990-91)		POST-REFOM PERIOD (1991-92 TO 2016-17)					
YEAR	**TFPG**	**YEAR**	**TFPG**	**YEAR**	**TFPG**	**YEAR**	**TFPG**
1980-81	-0.1357	**1991-92**	-0.0068	**2002-03**	0.0505	**2013-14**	-0.0310
1981-82	0.0059	**1992-93**	0.0553	**2003-04**	0.0008	**2014-15**	-0.0359
1982-83	0.0560	**1993-94**	0.1400	**2004-05**	0.0311	**2015-16**	-0.0230
1983-84	0.1143	**1994-95**	0.0905	**2005-06**	0.0698	**2016-17**	-0.0027
1984-85	0.0651	**1995-96**	-0.0281	**2006-07**	0.0844		
1985-86	0.0388	**1996-97**	0.0573	**2007-08**	-0.0423		
1986-87	0.0700	**1997-98**	0.0181	**2008-09**	-0.0662		
1987-88	0.0325	**1998-99**	-0.0181	**2009-10**	0.1023		
1988-89	0.0449	**1999-2000**	-0.0021	**2010-11**	0.1537		
1989-90	0.1840	**2000-01**	0.0341	**2011-12**	-0.1041		
1990-91	0.0766	**2001-02**	-0.0825	**2012-13**	0.1862		
ANNUAL AVERAGE	0.0502		0.0234		0.0424		-0.0232

Source: Author's own estimation

Manufacture of Food Products and Beverages

This division of food products includes the processing of the products of agriculture, forestry and fishing into food for humans or animals, and includes the production of various intermediate products that are not directly food products, such as, Processing and preserving of meat, fish, crustaceans and fruit and vegetables. It also includes manufacture of vegetable and animal oils and fats, dairy products, grain mill products, starches and starch products, Manufacture of prepared animal feeds. On the other hand, the manufacture of beverages includes non-alcoholic beverages and mineral water, manufacture of alcoholic beverages mainly through fermentation, beer and wine, and the manufacture of distilled alcoholic beverages.

We merge these two manufacturing industries for data comparability of different National Industrial Classification (NIC). Now, we discuss the trend growth rate of TFP of Manufacture of Food Products and Beverages industry.

Table-7: TFPG of Manufacture of Food Products and Beverages

PRE-REFOM PERIOD (1980-81 TO 1990-91)		POST-REFOM PERIOD (1991-92 TO 2016-17)					
YEAR	**TFPG**	**YEAR**	**TFPG**	**YEAR**	**TFPG**	**YEAR**	**TFPG**
1980-81	0.2574	**1991-92**	0.0817	**2002-03**	0.0010	**2013-14**	0.0000
1981-82	0.2918	**1992-93**	0.0480	**2003-04**	-0.0288	**2014-15**	-0.0050
1982-83	0.2281	**1993-94**	0.1258	**2004-05**	0.0354	**2015-16**	0.0303
1983-84	0.2114	**1994-95**	0.1117	**2005-06**	0.0799	**2016-17**	0.0582
1984-85	0.0904	**1995-96**	0.0194	**2006-07**	0.1544		
1985-86	0.0925	**1996-97**	0.0685	**2007-08**	-0.0250		
1986-87	0.0940	**1997-98**	0.0208	**2008-09**	0.0551		
1987-88	0.1102	**1998-99**	0.0876	**2009-10**	0.0088		
1988-89	0.1011	**1999-2000**	-0.0096	**2010-11**	0.0846		
1989-90	0.1264	**2000-01**	-0.0245	**2011-12**	0.1014		
1990-91	0.0303	**2001-02**	0.0092	**2012-13**	-0.0348		
ANNUAL AVERAGE	0.1485		0.0490		0.0393		0.0208

Source: Author's own estimation

For Food Products and Beverages industry shows a sharply declining trend growth rate of total factor productivity. Therefore, over the time technology is not properly upgraded for that industry.

Manufacture of Rubber and Plastic Products

Manufacture of rubber and plastics products is characterized by the raw materials used in the manufacturing process. However, this does not imply that the manufacture of all products made of these materials is classified here. Under this manufacturing industry, there are two sub-sectors, Manufacture of rubber products, Manufacture of plastics products. This Small-scale sector (SSI) produces highly labour-intensive products in which the technology gap with capital intensive production techniques may not have mattered.

Table-8: TFPG of Manufacture of Rubber and Plastic Products

PRE-REFOM PERIOD (1980-81 TO 1990-91)		POST-REFOM PERIOD (1991-92 TO 2016-17)					
YEAR	**TFPG**	**YEAR**	**TFPG**	**YEAR**	**TFPG**	**YEAR**	**TFPG**
1980-81	0.0513	**1991-92**	0.1154	**2002-03**	0.0230	**2013-14**	0.2305
1981-82	0.1369	**1992-93**	0.1523	**2003-04**	0.0136	**2014-15**	-0.0186
1982-83	0.3645	**1993-94**	0.0763	**2004-05**	0.0442	**2015-16**	0.0090
1983-84	0.1475	**1994-95**	0.0160	**2005-06**	-0.0590	**2016-17**	0.0275
1984-85	0.2447	**1995-96**	0.1426	**2006-07**	0.0190		
1985-86	0.0866	**1996-97**	0.1126	**2007-08**	0.2124		
1986-87	0.1405	**1997-98**	0.1451	**2008-09**	0.2759		
1987-88	0.0675	**1998-99**	-0.0194	**2009-10**	0.0705		
1988-89	0.1647	**1999-2000**	0.0978	**2010-11**	0.1676		
1989-90	0.0318	**2000-01**	-0.1161	**2011-12**	-0.0905		
1990-91	0.1338	**2001-02**	0.0945	**2012-13**	-0.0402		
ANNUAL AVERAGE	0.1427		0.0743		0.0579		0.0621

Source: Author's own estimation

Rubber and Plastic Products, in which, TFPG is decelerated in the two sub-periods (0.1427%, 0.0743%, 0.0579%). However, TFPG increased to 0.0621% per annum in the third sub-period of the post-reform period.

Manufacture of Coke, Refined Petroleum Products and Nuclear Fuel

This division includes the transformation of crude petroleum and coal into usable products. The dominant process is petroleum refining which involves the separation of crude petroleum into component products through such techniques as cracking and distillation. This division also includes the manufacture for own account of characteristic products (e.g. coke, butane, propane, petrol, kerosene, fuel oil etc.) as well as processing services (e.g. custom refining). In our study, we try to show the growth rate of total factor productivity and found out that there is a haphazard growth rate. But, in the pre-reform period, TFPG is higher compared to other industries, as because in addition the Petroleum refinery industry also benefited from continued high protection, which allowed the private sector to take risks in bringing in the frontier technologies and world beating technologies.

Table-9: TFPG of Manufacture of Coke, Refined Petroleum Products and Nuclear Fuel

PRE-REFOM PERIOD (1980-81 TO 1990-91)		POST-REFOM PERIOD (1991-92 TO 2016-17)					
YEAR	TFPG	YEAR	TFPG	YEAR	TFPG	YEAR	TFPG
1980-81	0.0227	**1991-92**	-0.1028	**2002-03**	0.6903	**2013-14**	-0.1435
1981-82	0.2366	**1992-93**	0.5119	**2003-04**	0.1645	**2014-15**	0.1833
1982-83	0.5138	**1993-94**	0.1260	**2004-05**	0.1021	**2015-16**	-0.0052
1983-84	-0.3887	**1994-95**	0.0738	**2005-06**	0.1974	**2016-17**	-0.0018
1984-85	0.6958	**1995-96**	0.1365	**2006-07**	0.0633		
1985-86	1.1598	**1996-97**	0.0580	**2007-08**	0.1046		
1986-87	-0.0251	**1997-98**	-0.4489	**2008-09**	0.0003		
1987-88	0.1459	**1998-99**	0.7281	**2009-10**	-0.1269		
1988-89	0.0067	**1999-2000**	-0.1517	**2010-11**	0.1184		
1989-90	0.1601	**2000-01**	0.2635	**2011-12**	-0.2899		
1990-91	0.0761	**2001-02**	0.1937	**2012-13**	0.7236		
ANNUAL AVERAGE	0.2367		0.1262		0.1589		0.0082

Source: Author's own estimation

Manufacture of Chemical and Chemical Products Industry

This division includes the transformation of organic and inorganic raw materials by a chemical process and the formation of products. It distinguishes the production of basic chemicals that constitute the first industry group from the production of intermediate and end products produced by further processing of basic chemicals that make up the remaining industry classes.

For the chemical & chemical product industry, the development pace of TFP is reducing up to second sub-period (2002-03 to 2012-13), there after it is expanding (0.0514%, 0.0498%, 0.0054%, and 0.0291%). By and large, India had a favourable position in semi-gifted work concentrated synthetic substances and not in capital escalated or high innovation ones. These eventual influenced to various degrees and have various velocities of recuperation. This industry is portrayed by a decent variety of items and makers (counting some little scope ones) with the goal that the dispersion of innovation may have been slower.

Table-10: TFPG of Manufacture of Chemical and Chemical Products Industry: -

PRE-REFOM PERIOD (1980-81 TO 1990-91)		POST-REFOM PERIOD (1991-92 TO 2016-17)					
YEAR	**TFPG**	**YEAR**	**TFPG**	**YEAR**	**TFPG**	**YEAR**	**TFPG**
1980-81	-0.1424	**1991-92**	0.0784	**2002-03**	0.0364	**2013-14**	-0.0196
1981-82	0.0608	**1992-93**	0.1954	**2003-04**	-0.0022	**2014-15**	-0.0438
1982-83	0.0871	**1993-94**	0.0584	**2004-05**	0.0443	**2015-16**	0.2331
1983-84	0.0990	**1994-95**	0.0650	**2005-06**	0.0291	**2016-17**	-0.0533
1984-85	0.0288	**1995-96**	0.1612	**2006-07**	0.0160		
1985-86	0.0661	**1996-97**	-0.0334	**2007-08**	0.0133		
1986-87	0.0298	**1997-98**	-0.0098	**2008-09**	-0.1992		
1987-88	0.1137	**1998-99**	0.1666	**2009-10**	0.0408		
1988-89	0.0544	**1999-2000**	-0.0007	**2010-11**	0.0168		
1989-90	0.1061	**2000-01**	-0.0869	**2011-12**	0.0799		
1990-91	0.0616	**2001-02**	-0.0461	**2012-13**	-0.0162		
ANNUAL AVERAGE	0.0514		0.0498		0.0054		0.0291

Source: Author's own estimation

Manufacture of Motor Vehicles, Trailers and Semi-Trailers

This division includes the manufacture of motor vehicles for transporting passengers or freight. The manufacture of various parts and accessories, as well as the manufacture of trailers and semi-trailers, is included here, namely, Manufacture of motor vehicles, Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semitrailers, manufacture of parts and accessories for motor vehicles. Most of the sub-sectors are labour intensive in nature. One of the highest technological gaps (from the global frontier) was in the Automobile sector, particularly in personal cars. The technology in Transport vehicles like trucks was what may be termed "appropriate technology," not quite at the global frontier.

Table-11: TFPG of Manufacture of Motor Vehicles, Trailers and Semi-Trailers

PRE-REFOM PERIOD (1980-81 TO 1990-91)		POST-REFOM PERIOD (1991-92 TO 2016-17)					
YEAR	**TFPG**	**YEAR**	**TFPG**	**YEAR**	**TFPG**	**YEAR**	**TFPG**
1980-81	0.0407	**1991-92**	0.0481	**2002-03**	0.1252	**2013-14**	-0.1352
1981-82	0.2917	**1992-93**	0.0489	**2003-04**	0.2668	**2014-15**	0.2068
1982-83	0.1526	**1993-94**	0.0671	**2004-05**	0.2103	**2015-16**	0.0828
1983-84	-0.0018	**1994-95**	0.1990	**2005-06**	0.1493	**2016-17**	-0.0458
1984-85	0.0742	**1995-96**	0.4664	**2006-07**	-0.0656		
1985-86	0.1199	**1996-97**	0.0055	**2007-08**	0.0116		
1986-87	0.1204	**1997-98**	-0.0797	**2008-09**	-0.0885		
1987-88	-0.0252	**1998-99**	-0.0746	**2009-10**	0.3086		
1988-89	0.1772	**1999-2000**	0.1511	**2010-11**	0.0275		
1989-90	0.0990	**2000-01**	-0.1636	**2011-12**	0.1489		
1990-91	0.1499	**2001-02**	0.0252	**2012-13**	0.0544		
ANNUAL AVERAGE	0.1090		0.0630		0.1044		0.0271

Source: Author's own estimation

TFPG increased at 0.1090% per annum during the 1980s, eased back to 0.0630 %per annum in the primary sub-time of the 1990s change and expanded 0.1044% during the second sub-time frame. From there on all out-factor productivity growth decelerated strongly to 0.0271 % per annum in the third sub-time frame multiple occasions the TFPG during the 1980s.

Manufacture of Basic Metals Industry:

This industry includes the activities of smelting and/or refining ferrous and non-ferrous metals from ore, pig or scrap, using electro metallurgic and other process metallurgic techniques. This division also includes the manufacture of metal alloys and super-alloys by introducing other chemical elements to pure metals. The output of smelting and refining, usually in ingot form, is used in rolling, drawing and extruding operations to make products such as plate, sheet, strip, bars, rods or wire, and in molten form to make castings and other basic metal products.

TABLE-12: TFPG of Manufacture of Basic Metals Industry

PRE-REFOM PERIOD (1980-81 TO 1990-91)		POST-REFOM PERIOD (1991-92 TO 2016-17)					
YEAR	**TFPG**	**YEAR**	**TFPG**	**YEAR**	**TFPG**	**YEAR**	**TFPG**
1980-81	-0.0101	**1991-92**	-0.0714	**2002-03**	0.2610	**2013-14**	0.2053
1981-82	0.1677	**1992-93**	0.2372	**2003-04**	0.1779	**2014-15**	-0.1377
1982-83	0.0416	**1993-94**	0.0410	**2004-05**	0.3272	**2015-16**	-0.2530
1983-84	0.0909	**1994-95**	0.1435	**2005-06**	-0.1172	**2016-17**	0.0688
1984-85	0.0228	**1995-96**	0.1419	**2006-07**	0.1806		
1985-86	0.1277	**1996-97**	-0.0618	**2007-08**	0.1493		
1986-87	-0.0231	**1997-98**	0.2089	**2008-09**	-0.1354		
1987-88	0.1249	**1998-99**	-0.0950	**2009-10**	-0.0147		
1988-89	0.2280	**1999-2000**	0.0007	**2010-11**	0.0177		
1989-90	0.0152	**2000-01**	-0.1624	**2011-12**	-0.0095		
1990-91	0.1414	**2001-02**	-0.0706	**2012-13**	-0.0761		
ANNUAL AVERAGE	**0.0843**		**0.0284**		**0.0692**		**-0.0291**

Source: Author's own estimation

Basic Metals industry shows a declining trend growth rate of total factor productivity in 1st sub-period. In the 2nd sub-period, it is increasing and again TFPG declining sharply. Therefore, over the time technology is not properly upgraded for that industry. We may also conclude that in Indian Metal sector there was a huge portion of unorganised labour employment. So, they do not use capital intensive technology. Therefore, there is a scope to upgrade technology, unless productivity growth is negative after some year.

Other Manufacture Industry:

The study uses two-digit level of ASI manufacturing industries. Within manufacturing sector, the study focuses only on industries having the highest share in the total value added of the manufacturing sector in India during the study period. On this basis, the following 9 industries comprising of 65.79% shares in Gross Value Added (GVA) were selected for the analysis: (1) Food products & beverages (7.60%), (2) Chemicals & chemical products (9.95%); (3) Basic metals (8.12%); (4) Textiles products (4.84%); (5) Coke, petroleum products & nuclear fuel (12.87%); (6) Machinery & equipment n.e.c (5.70%); (7), Motor vehicles, trailers & semi-trailers (7.68%) ; (8)) Non-metallic Mineral products (5.02 %); (9) Rubber and Plastic products (4.01%). The remaining two-digit industries, accounting for remaining 34.21% share in the aggregate manufacturing sector, were put together in a category defined as 'Others Manufacturing Industry'.

Table-13: TFPG of Other Manufacture Industry

PRE-REFOM PERIOD (1980-81 TO 1990-91)		POST-REFOM PERIOD (1991-92 TO 2016-17)					
YEAR	**TFPG**	**YEAR**	**TFPG**	**YEAR**	**TFPG**	**YEAR**	**TFPG**
1980-81	-0.0345	**1991-92**	0.0450	**2002-03**	0.0374	**2013-14**	0.0091
1981-82	0.0900	**1992-93**	0.0933	**2003-04**	0.0143	**2014-15**	-0.0066
1982-83	0.0699	**1993-94**	0.0668	**2004-05**	0.0329	**2015-16**	0.0120
1983-84	0.1060	**1994-95**	0.0362	**2005-06**	0.0829	**2016-17**	-0.0233
1984-85	0.0252	**1995-96**	0.0530	**2006-07**	0.0754		
1985-86	0.0222	**1996-97**	-0.0226	**2007-08**	0.0315		
1986-87	0.0771	**1997-98**	0.0463	**2008-09**	0.1659		
1987-88	0.0579	**1998-99**	-0.1816	**2009-10**	0.0522		
1988-89	0.0381	**1999-2000**	0.0000	**2010-11**	0.0519		
1989-90	0.0775	**2000-01**	-0.0141	**2011-12**	0.0301		
1990-91	0.0543	**2001-02**	0.0156	**2012-13**	-0.0126		
ANNUAL AVERAGE	0.0530		0.0125		0.0511		-0.0022

Source: Author's own estimation

TFP grew at 0.0530 per cent per annum in the 1980s, slowed to 0.0125 per cent per annum in the first sub-period of the post- reform and increased (0.0511 per cent) during the second sub-period.

Thereafter total factor productivity growth decelerated sharply to -0.0022 per cent per annum in the third sub-period.

TABLE-14: TFP Growth in Indian Manufacturing Sub-Sectors

PERIOD	ME	ONMP	TXT	FP&B	R&PP	CRPP &NF	C&CP	MVT&ST	BM	OTHERS
PERIOD-I (1980-81 TO 1990-91)	0.0735	0.1677	0.0502	0.1485	0.1427	0.2367	0.0514	0.1090	0.0843	0.0530
PERIOD-II (1991-92 TO 2016-17)	0.0290	0.0407	0.0142	0.0364	0.0647	0.0978	0.0281	0.0649	0.0228	0.0205
SUB-PERIOD I (1991-92 to 2001-02)	0.0389	0.0591	0.0234	0.0490	0.0743	0.1262	0.0498	0.0630	0.0284	0.0125
SUB-PERIOD II (2002-03 TO 2012-13)	0.0711	0.0613	0.0424	0.0393	0.0579	0.1589	0.0054	0.1044	0.0692	0.0511
SUB-PERIOD III (2013-14 TO 2016-17)	-0.0230	0.0017	-0.0232	0.0208	0.0621	0.0082	0.0291	0.0271	-0.0291	-0.0022
STUDY PERIOD (1980-81 TO 2016-17)	0.0520	0.0858	0.0320	0.0726	0.0884	0.1560	0.0348	0.0851	0.0509	0.0344
CURVE PATTERN	J-	J-	J-	decreased	J	J-	J	J-	J-	J-

Source: Author's own estimation

Abbreviations: FP&B = Food Products & Beverages; TXT= Textile Products; CRPP&NF= Coke, Refined Petroleum Products, & Nuclear Fuel; C&CP= Chemicals & Chemicals Products; R&PP= Rubber & Plastic Products; ONMP= Other Non-Metallic Mineral Products; BM= Basic Metals; ME = Machinery & Equipments (N.E.C.); MVT&ST =Motor Vehicles, Trailers & Semi- Trailers

Manufacturing Sub-Sectors

Productivity growth across manufacturing sub-sectors substantially conforms to the trend of productivity growth found for total manufacturing. Except Food Products and Beverages Industry, all those sub-sectors of manufacturing TFPG followed the J curve pattern. For, Food Products and Beverages industry TFPG has decreased over the time period. Out of ten major manufacturing industry only two industries, such as, Rubber and Plastic Products and Chemical and Chemical Products industry has followed purely J curve pattern. Rest of the seven industries has followed J- curve pattern. All those ten sub-sectors of manufacturing TFPG has decreased in the post-reform period compared to the pre-reform period. The J- curve pattern occurs when TFPG falls in the 1st sub-period, but increase in the 2nd sub-period and again falls in the 3rd sub-period. On the other hand, J curve pattern occurs when the TFPG falls in the 1st two sub-periods and increases in the 3rd sub-period. In the entire time period, TFPG has highest for the Coke, Refined Petroleum Products and Nuclear fuel. Negative TFPG has occurred for Machinery and Equipments, Textile, Basic Metal and 'Others' industry.

<u>Comparison between Arvind Virmani and Danish A. Hashim, IMF Working Paper and Our Study:</u>

Virmani and Hashim's (2011) has pointed out the J-curve and S-curve productivity theory. According to them, Manufacture of Textile, Food Products and Beverages, Rubber and Plastic Products and Chemical and Chemical Products Industry follow J- Curve effect on TFPG. Machinery and Equipment's Industry and Coke, Refined Petroleum Products and Nuclear Fuel Industry have S-curve effect on TFPG and they also get a hybrid S-J effect on TFPG for Basic Metal, Other Non-metallic Mineral Products and Motor Vehicle, Trailers and Semi- trailers industry. Whereas, in our study, from Table-15, we have found that the TFPG for Machinery and Equipments, Other Non-metallic Mineral Products, Textile, Coke, Refined Petroleum Products and Nuclear Fuel, Motor Vehicle, Trailers and Semi- trailers, Basic Metal and 'Other' industries follow J- curve pattern. In our analysis, we get a declined trend growth rate for Food Products and Beverages industry. Chemical and Chemical Products and Rubber and Plastic Products industries followed J curve pattern.

Table- 15: Comparison between two studies

	ME	ONMP	TXT	FP&B	R&PP	CRPP &NF	C&CP	MVT&ST	BM
Virmani & Hashim	**S-**	**S=>J**	**J**	**J**	**J**	**S**	**J**	**S=>J**	**S=>J**
Our study	**J**	**J**	**J**	**Decreased**	**J**	**J**	**J**	**J**	**J**

Source: Virmani & Hashim and Authors own estimation

Abbreviations: FP&B = Food Products & Beverages; TXT= Textile Products; CRPP&NF= Coke, Refined Petroleum Products, & Nuclear Fuel; C&CP= Chemicals & Chemicals Products; R&PP= Rubber & Plastic Products; ONMP= Other Non-Metallic Mineral Products; BM= Basic Metals; ME = Machinery & Equipments (N.E.C.); MVT&ST =Motor Vehicles, Trailers & Semi- Trailers

Total Factor Productivity (TFP) and its components:

In this section, TFP, cost shift and non-constant returns to scale have been computed from the parametric estimates of the trans-log cost function. Hence, TFP and its components decomposition results of some selected Indian manufacturing industries for the entire period and for the four decades have been reported in Table -16.

Table-16: Decadal Decomposition of Total Factor Productivity (TFP) of all Selected Manufacturing Industries

Decades	Total Factor Productivity	Shift of cost Function ($-\dot{\Theta}$)	Non-constant Returns to scale

	Growth (TFP)		(1-η_{CQ})$\dot{Q}$
First	0.1133	0.0480	0.0653
Second	0.0691	0.0137	0.0555
Third	0.0564	0.0041	0.0522
Forth	0.0247	-0.0030	0.0276
Overall	0.0692	0.0172	0.0520

Source: Author's own estimation

From Table-16, we find that the TFP growth for the selected manufacturing industries for the entire period (1980-81 to 2016-17) is positive and it is 0.0692. We also observed that rate of growth of TFP is decline over decades. This result may be obtained due to technological progress or scale effect.

Technological progress in production is best reflected through a shift down in cost function. The negative (positive) sign associated with the parameter implies a shift down (up) in the cost of production. From the above table we may conclude that cost function is shifted down in the last decade and technology is rapidly growing in the last decade (2010-11 to 2016-17) compare to another three decades. Hence, Technology is progressed over time.

Returns to scale parameter indicates the proportionate increase in output for a proportionate increase in all inputs. When the parameter is numerically less than one, it is suggestive of the operation of diminishing returns to scale. We find out there is decreasing return to scale in each and every decade and also in the entire period.

The above analysis exhibited that, when diminishing returns to scale operates the growth rate of TFP decreases and technological progress is also present over the decades.

Growth rates of real inputs, cost and output of rice across season, size and period are presented in Table-17.

Table-17: Average annual growth rates of real Inputs, Output and Cost of all Selected Manufacturing Industries

Decade	Output¿)	Total Factor Inputs $(\dot{F})$	Labour $(\dot{L})$	Capital $(\dot{K})$	Cost ¿
First	**0.1216**	**0.0199**	**0.0129**	**0.0219**	**0.0846**
Second	**0.1035**	**0.3193**	**0.0195**	**0.3998**	**0.1837**
Third	**0.0800**	**0.0456**	**0.0408**	**0.0253**	**0.0905**
Forth	**0.0391**	**0.0440**	**0.0397**	**0.1014**	**0.1477**
Overall	**0.0898**	**0.1123**	**0.0273**	**0.1400**	**0.1249**

Source: Author's own estimation

The factors, like, labour force, capital showed a positive growth rate in manufacturing sector and the growth rate is high for capital. It is further noted that the growth rate of real cost of production almost always remained more than the growth rate in output. It all shows that there were severe constraints in the production process that prevented them from using more inputs.

Now, we observe, how the share of each factor of production behaved in production function in different decades? The input share in total cost over the decade is reported in Table-18.

Table-18: Share of Factor Inputs in Total Cost

Decade	Labour	Capital
First	**0.2316**	**1.7256**
Second	**0.2385**	**2.1389**
Third	**0.4793**	**2.6069**
Forth	**0.8887**	**2.6974**
Overall	**0.4247**	**2.2593**

Source: Author's own estimation

From the above table, we may conclude that, the share of labour is less than the share of capital for the entire period and also in sub-periods. So, our selected industries are capital intensive in nature.

4. Summary and conclusion:

Bigger piece of the literature examines the impact of the reforms initiated during mid-1991 on the Indian manufacturing industries has found that the TFPG has declined when appeared differently in relation to the pre-reform period. One of the significant explanations behind this falling pattern in TFPG was under-use of the current limit of the organizations. In this background, the current examination is a push to evaluate the TFPG and its part for some chose fabricating ventures in India by utilizing cost-function approach throughout the year 1980-81 to 2016-17. The huge timespan, that is considered in our examination, offers us a chance to rethink the current realities with a sub-decadal investigation. We have likewise attempted to assess the yearly normal development pace of yield, factor data sources and cost to fabricate an alluring and relative examination among the decades.

In this setting, the significant discoveries of our investigation can be summed up as follows:

In the first place, the impact of economic reforms on the aggregate Indian manufacturing industries shows a declining pattern of TFPG throughout the decades. In this manner, it might be inferring that, advancement adversely affects TFP growth for Indian manufacturing industries.

Second, our investigation additionally affirms that TFPG is negative in the greater part of cases.

Third, Annual average growth of factor inputs, output and cost of all selected manufacturing industries are sure throughout the decades.

In such manner, the J & S curve productivity speculation as proposed by Virmani (2005) and Virmani (2009) is just bolstered by the Indian Textile industry, Rubber and Plastic Product industry and Chemical and Chemical item industry. But, for the rest of the industries only J curve productivity theory holds except for Indian food products and beverages industry.

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