Productivity Change in Indian Manufacturing: A Comparison of Pre Reform and Post Reform Period

Anubhuti Dwivedi
Professor & Associate Dean, Asian Business School, Noida

Maroof Ahmad
Assistant Professor, Asian Business School, Noida

Abstract

The economic reforms were initiated in 1991 as part of the structural adjustment programme in India. It constituted of the three-pronged approach of Liberalization, Privatization and Globalization to boost investment, production and productivity in the economy. This paper attempts to analyse the trend of, technical efficiency, technological change and TFP growth in the Indian manufacturing sector during 1981-82 to 2011-12. The period up to 1990-91 is considered as pre-reform while the subsequent period is regarded as post-reform. The data used in this study for calculating productivity and its various components have been sourced from the Annual Survey of Industries (ASI) for the relevant years. The manufacturing sector is modelled as an industry producing a scalar output measured by the gross value added at constant prices by employing two-factor inputs namely labour and capital. Data Envelopment Analysis based Malmquist Index has been calculated to arrive at the estimates of technical efficiency, technological change and total factor productivity growth and a comparison has been made between pre-reform and post-reform period.

Keywords: *Economic Reforms, Total Factor Productivity, Technical Efficiency, Technological Change, Malmquist Index, Data Envelopment Analysis*

Introduction

Productivity change is both the cause and the consequence of the dynamic forces operative in an economy. The concept of productivity and its various aspects have been discussed and debated in economic literature ever since Solow (1957) decomposed output growth into the contribution of input growth and a residual productivity term. The basic premises on which the industrial growth depends in the developing economies is the growth in the total factor productivity as there are resource constraints in these economies and production has to be raised given the limited amount of resources. The competitiveness of a firm or industry goes up due to technological progress and changes in technical efficiency.

The technological progress occurs through changes in the best practice production frontier, while efficiency increases when firms move closer to this frontier. Thus, the total factor productivity change is the sum of the rate of technological progress and changes in technical efficiency (Fare et. al. 1994).

One can identify four distinct phases of industrial growth in India since the inception of planning. The first phase 1956-65 was a period of rapid growth. The second phase of slow growth or deceleration extends from 1965-66 to 1979-80. The third phase is a phase of recovery and revival of growth since the 1980s. The fourth phase started with the 1991 economic policy reforms. During the 1980s, the government became supportive towards business but the steps taken were not concerted in the effort. Rodrik and Subramanian (2004) have characterised the policy changes of the

1980s and 1991 as pro-business and pro-market reforms, respectively. The economic reforms of 1991 focused on removing the bottlenecks in the markets through economic liberalisation by favouring new competition.

In this paper, estimates of total factor productivity (TFP) growth and its components technical efficiency and technological change are presented for Indian manufacturing and major industry groups for the period 1981–82 to 2011– 12. The objective is to compare the growth rate of TFP in Indian industries in the post-reform period, i.e. after 1991 with that in the pre-reform period of the 1980s.

Earlier Studies

Some of the prominent studies that examined the effect of policy reforms, particularly, trade policy reforms, on technical efficiency include Tybout et al. (1991) which analysed the effect of Chilean trade liberalisation on industrial efficiency and found that reduction in tariff protection is correlated with an increase in efficiency and decreases in variance of the efficiency scores. However, their results also show that eleven out of twenty-one industries included in the study registered a decline in the level of efficiency after the trade reform. The study by Alam and Morrison (2000) in the case of Peru shows that fifteen out of the twenty industries studied experienced an increase in efficiency after the trade reform. Tybout and Westbrook (1995) examine whether the changes in efficiency after the reform is correlated with changes in various measures of trade policy in Mexico. In an Indian context, a number of studies examined the effect of trade policy reform on total factor productivity in the nineties and these include studies by Balakrishnan et al. (2001), Krishna and Mitra (1998) and Kusum Das (1998). The study by Balakrishnan et al. (2001) used firm-level panel data of industries that faced a greater reduction in trade protection for the period 1988-89 to 1997-98. This study found that productivity growth is lower in the post-reform period. Krishna and Mitra (1998) also used firm-level panel data of some selected industries for the period 1986-1993. However, this study also could not find strong evidence for the productivity effect of the reform. The study by Kusum Das (1998) analysed seventy-six three-digit industries covering the period 1980-81 to 1993-94 and found that productivity response to the trade policy reform is mixed. There are also studies that examined the technical efficiency of the manufacturing industry in the 1990s. These include Agarwal (2001), who analyses the performance of some selected public sector firms in terms of their technical efficiency. Agarwal and Goldar (1999) focus on the state-wise analysis of technical efficiency of the manufacturing industry for the period 1976-77 to 1992-93. Parmeswaram (2002) found that all the industries considered for this research paper registered a higher rate of technical progress in the post-reform period along with a decline in the level of technical efficiency.

Empirical Methodology

The concept of TFP growth date back to the work of Tinbergen (1942), Abramotivz (1956), Solow (1957), and Griliches and Jorgenson (1966) among many others. While these and a significant number of studies thereafter have often focused on the non-frontier approach to calculating TFP growth, the frontier approach to TFP measurement was first initiated by Farrell (1957). The frontier and non-frontier categorization are of methodological importance since the frontier approach identifies the role of technical efficiency in overall firm performance while the non-frontier approach assumes that firms are technically efficient.

Technical efficiency can be measured by the ratio of observed to maximum potential output given all the inputs and outputs observed in the economy (Farrell, 1957). In parametric models, an explicit functional form can be given to the production frontier which traces the set of maximum output obtainable from a given set of inputs and technology, and its parameters are econometrically estimated using observed inputs and outputs. The resulting measure of total factor productivity and technical efficiency depends crucially on the adopted functional form, which, if misspecified, may bias the efficiency estimate. Under the non-parametric approach of Data Envelopment Analysis (DEA), a frontier refers to a bounding function, or more appropriately, a set of best obtainable positions. The production frontier is an unobservable function that is said to represent the 'best practice' function as it is a function bounding or enveloping the sample data.

The non-parametric measure of total factor productivity (TFP) change indices can be obtained by using the DEA-based Malmquist productivity index method described in Fare et al (1994) and Coelli, Rao and Battese (1998). This technique enables a change in TFP to be decomposed into two components, one measuring the change in efficiency (movements towards the production frontier) and the other measuring the change in the frontier technology (shifts in the frontier).

The Malmquist index is defined using distance functions. Distance functions allow one to describe a multi-input, multi-output production technology without the need to specify a behavioural objective (such as cost minimization or profit maximization). One may define input and output distance functions as input distance function characterises the production technology by looking at a minimal proportional contraction of the input vector, given an output vector. An output distance function considers a maximal proportional expansion of the output vector, given an input vector. This paper considers only an output distance function.

The Malmquist TFP index measures the TFP change between two data points (for example, those of a particular firm in two adjacent time periods) by calculating the ratio of the distances of each data point relative to a common technology. Following Färe et al (1994), the Malmquist (output-orientated) TFP change index between period t (the base period) and period t+1 is given by

(1)

where the notation Dot+1(xt,yt) ,

$$M_0\left(x^{t+1},y^{t+1},x^t,y^t\right)=\left[\left(\frac{D_0^t\left(x^{t+1},y^{t+1}\right)}{D_0^t\left(x^t,y^t\right)}\right)\left(\frac{D_0^{t+1}\left(x^{t+1},y^{t+1}\right)}{D_0^{t+1}\left(x^t,y^t\right)}\right)\right]^{\frac{1}{2}}$$

represents the distance from the period t+1 observation to the period t technology, x^t is the input and y^t is the output in period t. A value of M_O greater than one will indicate positive TFP growth from period t to period t+1 while a value less than one indicates a TFP decline. Note that the above equation is, in fact, the geometric mean of two TFP indices. The first is evaluated with respect to period t technology and the second with respect to period t+1 technology. An equivalent way of writing this productivity index is

(2)

where the ratio outside the square brackets

$$M_0\left(x^{t+1},y^{t+1},x^t,y^t\right)=\left(\frac{D_0^t\left(x^{t+1},y^{t+1}\right)}{D_0^t\left(x^t,y^t\right)}\right)\times\left[\left(\frac{D_0^t\left(x^{t+1},y^{t+1}\right)}{D_0^{t+1}\left(x^{t+1},y^{t+1}\right)}\right)\left(\frac{D_0^t\left(x^t,y^t\right)}{D_0^{t+1}\left(x^t,y^t\right)}\right)\right]^{\frac{1}{2}}$$

measures the change in the output-oriented measure of Farrell technical efficiency between periods t and t+1. That is, the efficiency change is equivalent to the ratio of the technical efficiency in period t+1 to the technical efficiency in period t. The remaining part of the index in the above equation is a measure of technical change. It is the geometric mean of the shift in technology between the two periods, evaluated at x^t+1 and also at x^t.

Hence the Malmquist productivity index is simply the product of the change in relative efficiency that occurred between period t and t+1, and the change in technology that occurred in the same periods. To calculate the Malmquist Productivity Index given in equation (1) we must calculate the four component distance functions, which will involve four linear programming problems (similar to those conducted in calculating Farell technical efficiency (TE) measures) [Coelli (1996)] .

Data and Variables

The data used in this study for calculating productivity and its various components come from the Annual Survey of Industries (ASI) for the relevant years. The two digit industry groups have been modelled as units producing a scalar output measured by the gross value added at constant prices by employing the factor inputs, labour and capital. The two-digit classification has been done according to NIC 2004 and the two-digit industry groups of NIC 1970, 1987 and 1998 have been concorded to NIC 2004 as per EPW Research Foundation suggestions.

Using gross value added at constant prices is a common practice in the Indian empirical literature (e.g., Unel, 2003; Ahluwalia, 1991; Balakrishnan and Pushpangadan, 1994; and Goldar, 1986). Using Gross value added rather than gross output allows comparison between the firms that are using heterogeneous raw materials (Griliches and Ringstad, 1971). The use of gross output in place of gross value added makes it essential to use raw materials in the analysis, which may obscure the role of labour and capital in the productivity growth (Hossain and Karunaratne, 2004). Use of gross value added is also advantageous in accounting for differences and changes in the quality of inputs (Salim and Kalirajan, 1999). ASI reports gross value added data in value terms. Nominal values of gross value added were deflated by the wholesale price index for manufactured goods.

Labour input is measured by the total number of persons engaged in an average establishment. ASI also reports fixed capital stock data in value terms. The fixed capital stock was deflated by the price index for new machinery and transport equipment. Both of these variables are measured at 1981-82 prices at all-India level. Measuring the capital stock input is rather problematic. In many studies capital stock is measured by the book value of fixed assets while in others its flow is measured by summing rent, repairs, and depreciation expenses or perpetual inventory created from annual investment data. Each of these measures has its own shortcomings. For example, the book value and perpetual inventory methods do not address the question of capacity utilisation, whereas the flow measurement may be questioned on the ground that the depreciation charges in the financial accounts may be unrelated to actual depreciation of hardware. Thus following Ray (2002) in the present study, the capital stock is measured by the book value of fixed assets.

Empirical Results

Data Envelopment Analysis (DEA) using panel data set is undertaken and output-oriented Malmquist indices are estimated which are further disaggregated into technical efficiency change indices and technological change indices. The average technical efficiency change, technological change and total factor productivity change in manufacturing industries during the pre-reform period 1981-82 to 1990-91 are reported in Table 1 and for the post-reform period which has been divided into two phases,Phase I: 1991-92 to 1999-2000 are reported in Table 2 and Phase II: 2001-02 to 2011-12 are reported in Table 3.

Table 1: Malmquist Index Summary for Pre Reform Period

* t-1 in year 1 is not defined, hence

YEAR	TEFFCH	TECHCH	SECH	PECH	TFPCH
1981-82	0.924	1.021	1.48	0.905	0.943
1982-83	0.802	1.235	1.00	0.649	0.990
1983-84	1.004	1.004	1.11	1.000	1.008
1984-85	0.969	1.149	0.90	0.843	1.113
1985-86	0.949	1.137	0.97	0.835	1.079
1986-87	0.938	1.176	0.93	0.798	1.103
1987-88	0.762	1.211	0.71	0.629	0.923
1988-89	0.749	1.247	1.72	0.601	0.934
1989-90	0.826	1.335	0.88	0.619	1.103
1990-91	0.979	1.025	1.00	0.955	1.003
Mean	**0.885**	**1.149**	**1.037**	**0.770**	**1.017**

Malmquist index cannot be calculated for the first year which in this study is 1980-81

Table1 gives the Malmquist index summary for the pre-reform period. It can be seen from the table that during the period 1980-81 to 1990-91, the Indian manufacturing sector exhibited positive TFP change. During this period, there was a fall in technical efficiency but a technological change was positive. Overall, the mean total factor productivity change during the pre-reform period covered in the study was positive.

Table 2 gives the Malmquist index summary for the first phase of the post-reform period. It can be seen from the table that during the period 1991-92 to 2000-2001, the Indian manufacturing sector exhibited positive TFP change. During this period too, there was a fall in technical efficiency but the technological change was positive. Overall, the mean total factor productivity change during the pre-reform period covered in the study was positive.

Table 2: Malmquist Index Summary for Post Reform Period (Phase I)

Table 3 gives the Malmquist index summary

YEAR	TEFFCH	TECHCH	SECH	PECH	TFPCH
1991-92	0.989	1.045	0.96	1.030	1.033
1992-93	1.005	1.048	0.948	1.060	1.053
1993-94	0.882	1.118	1.169	0.754	0.986
1994-95	1.004	1.098	0.873	1.150	1.102
1995-96	0.882	1.209	1.103	0.799	1.066
1996-97	0.852	1.166	1.018	0.837	0.994
1997-98	0.864	1.142	1.052	0.822	0.987
1998-99	0.891	1.114	0.947	0.941	0.993
1999-2000	0.971	1.016	1.023	0.950	0.987
2000-01	0.954	1.033	1.001	0.953	0.985
Mean	**0.928**	**1.097**	**1.006**	**0.922**	**1.018**

for the second phase of post-reform period. It can be seen from the table that during the period 2001-02 to 2011-12, the Indian manufacturing sector exhibited negative TFP change. During this period, there was a fall in technical efficiency and the positive technological change could not compensate for the fall in technical efficiency leading to a decline in overall mean total factor productivity change during this period.

Table 3: Malmquist Index Summary for Post Reform Period (Phase II)

YEAR	TEFFCH	TECHCH	SECH	PECH	TFPCH
2001-02	1.046	1.001	1.077	0.971	1.047
2002-03	1.045	1.017	1.093	0.956	1.063
2003-04	0.888	1.033	0.988	0.898	0.917
2004-05	1.009	1.119	1.030	0.980	1.129
2005-06	0.869	1.026	1.045	0.832	0.892
2006-07	1.145	1.105	0.763	1.500	1.265
2007-08	0.936	1.014	1.112	0.842	0.949
2008-09	0.774	1.215	0.767	1.009	0.940
2009-10	0.885	1.009	0.939	0.943	0.893
2010-11	0.974	1.072	1.092	0.892	1.044
2011-12	0.866	1.008	1.118	0.775	0.873
Mean	**0.943**	**1.054**	**0.994**	**0.949**	**0.995**

Conclusion

The result reveal that economic reforms initiated since 1991 had a positive impact on productivity in the beginning years but it was not very significant as the growth in productivity had already started in the 1980s with the supportive steps taken by the Government. The reforms of 1991 were, however, able to maintain the pace of productivity growth with the help of technological progress, though the overall technical efficiency in the manufacturing sector was declining. During the second phase of reforms, technological progress was not able to neutralize the impact of the decline in efficiency. This points to the fact that technology improvements were not accompanied by efficiency improvements and the measures to attract FDI for better management practices to enhance efficiency partially failed in its purpose. The lack of skill development required for an increase in efficiency along with technological progress may have been a reason for a decline in productivity in the later phase of reforms.

This paper has taken data at an aggregated level of industrial groups and the results for a more disaggregated level with specific sectors and firm-level data may provide more clarity on the results. Further research in this direction is called for to determine the effect of reforms on productivity.

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