Turkish Online Journal of Qualitative Inquiry (TOJQI)
Volume 12, Issue 10, October 2021: 345-358

Efficiency Improvement or Technological Advancement – What is influencing manufacturing productivity in India?

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Abstract

Ensuring that the benefits of growth are shared equitably requires a strong focus on greater convergence of regions in terms of output and productivity. The present study examines the regional disparities in Total Factor Productivity (TFP) in India by using the Data Envelopment Analysis (DEA) based non-parametric, Malmquist Productivity Index (MPI),especially in the post-crisis period. It utilises panel data for 3-digit industries from Annual Survey of Industries (ASI) for the period from 2003-04 to 2017-18 for 18 Indian states. The study period has been divided into a pre-crisis period (2003-2008) and post-crisis period (2008-2017) to see the impact of global financial crisis (GFC) on productivity as well. The results show that at the all India level, TFP of Organised Indian Manufacturing has declined in the post-crisis period as compared to pre-crisis period. The decomposition of the productivity growth further reveals that technological changes propelled growth in the pre-crisis period and efficiency changes were responsible for driving post-crisis growth. However, the inter-regional variations in productivity reduced during the post-crisis years signalling towards convergence of growth which is a welcome change. The author found that TFP is positively impacted by education, health and road infrastructure whereas relationship with telecommunication was found to be statistically insignificant.

Keywords: Total Factor Productivity (TFP), Malmquist Productivity Index (MPI), technical efficiency, technological change

Introduction

The growth of an economy is one of the most fundamental topics in economics and principally, it is governed by two distinct sources of growth, that is, input–driven and productivity–driven. The input–driven growth is achieved by the rise in factors of production which is subjected to diminishing returns to scale and is not sustainable in the long run. Productivity-driven growth refers to that portion of output growth that cannot be attributed to the growth in total inputs. It is generally attributed to the enhancement in knowledge, human resources, learning by doing, organizational structure, information technology and efficient use of factors of production.

Historically, rapid growth of industrial productivity has been a major driver of economic development. The faster the growth of industrial output, the faster the growth rate of real GDP. The reasons are that industry has the strongest input–output linkages which offer perfect opportunities for capital accumulation, technology sharing, exploiting economies of scale, and initiating positive knowledge spillover effects for other sectors of the economy (Storm, 2015). Price competitiveness of firms also depends vastly on their productivity. This then guides the global market share of these industries and their export potential as well.

In 1991, India introduced the new liberalisation policy to usher in new reforms in the economy's policy structure. One of the primary aims of the new economic policy was to enhance the productivity of the Indian economy. There have been several empirical studies which have evaluated the total factor productivity growth in the Indian manufacturing over different periods of time. Previous studies analysing the impact of economic policy on the economic development have largely been restricted either to the economy as a whole or to individual sectors for the manufacturing sector. Some studies show that productivity improved in the aggregate manufacturing sector in the post-reform years (Krishna and Mitra 1998, Prakash and Sinate 2000; Unel 2003). Others find evidence of decline (Goldar and Kumari 2003; Das 2004; Goldar 2004). Hence, the confirmation from pertinent empirical research remains largely ambiguous.

Literature Review

Productivity estimates for Indian states are essential as balanced regional development is one of the major ambitions of national policy in India. It will indicate resource use efficiency and thus the ability of the states to attain higher growth rates on a sustained basis (Kumar et el, 2012).However, there is a dearth of literature that exists for determining the total factor productivity of the states within India. Though extremely exhaustive in its scope, the KLEMS project (Goldar, 2014) also does not deal with state-wise figures of TFPG. One salient feature of the post-reform growth of India is that there has been a substantial ascent in regional disparities (Rao, 2009).

Another limitation of the current literature is that very few studies have tried to calculate the TFP of Indian manufacturing in the last decade (2010-2020) also referred to by some as the post financial crisis period. Even the studies which have done so have used the growth accounting framework for TFP estimation. The growth accounting approach is based on assumption of constant return to scale (CRS), perfect competition and requires specification of production function. This approach assumes that all resources are used efficiently and productivity gain/loss happens only on account of technical change. This is where the DEA based Malmquist productivity index (MPI) is more dominant for estimation of productivity growth as “DEA does not require any functional form” (Joshi & Singh, 2010; Mahadevan, 2002 and Raheman et al., 2008). Secondly, this approach allows the decomposition of productivity growth into Efficiency change (EC), Technical change (TC), and pure efficiency change (PEC) which is a substantial gain in informational content compared to growth accounting methods.

Thus, for the present study we have also applied the Malmquist productivity index to measure the total factor productivity growth and its components for Indian states in organised manufacturing. The most popular and source study in this regard (Fare et al., 1994) used a parametric approach to estimate productivity growth in 17 OECD countries within the period 1979 to 1988. This study found that American economy had above average productivity on account of technological change, while Japanese economy had the highest productivity due to advancements in technical efficiency. Mahadevan (2002) found the TFPG of Malaysia's manufacturing sector was low at 0.8% and it was driven by minute gains in both technical efficiency and technical change, with majority of industries operating close to optimum scale. Kumaret el (2012) calculated total factor productivity for Indian states and found convergence in the productivity growth over time.

The period from 2003-04 to 2007-2008 was characterized by high growth of manufacturing output at 8% per annum. According to Goldar (2014), there was an uplift in Total Factor Productivity Growth from 1.1% during 1980-1999 to 2.3% during 2000-2008. This spurt in output can be attributed to the pro-growth policies enacted by the economic reforms. However, the financial crisis of 2008 was a big impediment to the growth trajectory. Post the 2008 crisis, India's growth fell sharply and GDP growth slowed from 9% in 2007-08 to 5.8% in 2008-09. The average contraction in exports and imports had been around 28% during the Dec 2008-Sept 2009 period. With global trade on a decline, expansionary fiscal and monetary policies were deployed. The Reserve Bank of India (RBI) dropped interest rates from 7% to a low of 3.25%. The government bond yield reduced from 9% to 5% by 2008 end. The central government adopted an expansionary fiscal policy which expanded the fiscal deficit from 2.5% of GDP in 2008 to6.5% in 2010. All these policies had a positive influence on the economy and India was able to achieve a growth rate of 8% in GDP during 2010-11(RBI Bulletin).However, the pressure of high inflation and mounting fiscal deficit put pressure on the fiscal supported growth process and most expansionary policies were phased out by 2011.

However, in the long run, global uncertainty coupled with inadequate institutional capacity led to a decline in the domestic investment rates. The investment rate (gross fixed capital formation) which had reached a high of 38% of GDP in 2007-08, declined steadily to 30% of GDP almost a decade later in 2017-18.The saving rate followed similar trend and slipped from a peak of 36.4% to 29% during the same period (Nagraj 2020). Such a fall in saving and investment rates is unprecedented in recent times, implying a deep dent in the economy's growth potential. There were constraints at the supply side as well where the industrial capacity utilization rate dropped from 83%to 71% in 2016-17 (Nagraj 2020). This can be attributed to the reluctance of the banks to disburse risky loans and lack of domestic demand in the economy. Thus, an array of domestic and global turbulences resulted in relatively low growth post the crisis period. Hence, it should be interesting to corroborate this macro view with the more comprehensive view at the state level.

Objectives

For the analysis, we see the regional differences in Total Factor Productivity of organised manufacturing in Indian states and decompose the TFP growth into Technical change and efficiency change. I have also analysed the performance of the new states of Chhattisgarh, Jharkhand and Uttarakhand in comparison with their parent counterparts. In order to bring more credibility into the study, we compare our results with the growth accounting methodology and bring out the similarities and differences. In the end we look at the determinants of productivity and build a regression model to identify how significant is infrastructure development in the growth of industrial sector.

Research Methodology

To measure TFP at state level, we use the non-parametric linear programming (LP) that was introduced first by Charnes, Cooper and Rhodes (1978) known as CCR method, and further built onby Banker, Charnes and Cooper (1984) known as BCC method, with a view to measure and decompose the MPI of TFP.DEA approach is used to derive the efficient production frontier, against which we benchmark the technical efficiency of each firm. By letting the production frontier to move outwards and inwards over time due to technical change, the MPI can then be derived to measure the productivity change for an year relative to the previous year. The Malmquist index of Total Factor Productivity growth (M) is given by:

$$M_h^{t+1}\left(\mathbf{x}_h^t, \mathbf{y}_h^t, \mathbf{x}_h^{t+1}, \mathbf{y}_h^{t+1}\right) = \underbrace{\frac{D_h^{t+1}\left(\mathbf{x}_h^{t+1}, \mathbf{y}_h^{t+1}\right)}{D_h^t\left(\mathbf{x}_h^t, \mathbf{y}_h^t\right)}}_{EF_h^{t+1}} \underbrace{\left[\frac{D_h^t\left(\mathbf{x}_h^{t+1}, \mathbf{y}_h^{t+1}\right)}{D_h^{t+1}\left(\mathbf{x}_h^{t+1}, \mathbf{y}_h^{t+1}\right)} \frac{D_h^t\left(\mathbf{x}_h^t, \mathbf{y}_h^t\right)}{D_h^{t+1}\left(\mathbf{x}_h^t, \mathbf{y}_h^t\right)}\right]^{\frac{1}{2}}}_{TP_h^{t+1}}$$

Where $\mathbf{x}_h^t = (\mathbf{x}_1^t, \mathbf{x}_2^t \ldots. \mathbf{x}_n^t)$ denotes the input set and $\mathbf{y}_h^t = (\mathbf{y}_1^t, \mathbf{y}_2^t \ldots. \mathbf{y}_m^t)$ denotes the output set for firm h (h = 1,..., k) in period t. The first constituent, EF, is recognised as the productive efficiency chance between periods t and t+1, whereas the second constituent, TP, is recognised as the rate of technological change. Improvements in these constituents between periods t and t+1 are denoted by estimates larger than 1.We have represented the technology by the output possibility set as follows:

$$P^t(\mathbf{y}^t) = \{\mathbf{x}^t: (\mathbf{x}^t, \mathbf{y}^t) \in S^t\}, t = 1, \ldots \ldots, T$$

where $S^t = \{(x^t, y^t): x^t$ can produce $y^t\}$ is the technology set at period t. The output set provides us with all the set of feasible values for output that can be produced with the given input set. Let there be h=1,2,…..,H^t firms that produce M outputs $y_m^{k,t}$ where m = 1,2,3…M using N inputs $x_n^{k,t}$ where n = 1,2,3….N at each time period t=1,….,T. The standard Linear Programming Problem (LPP) model is solved to estimate technical efficiency of a firm h, compared to a best practice frontier. The equation is given by:

$$\begin{aligned} P^t(y^t) = \Bigg\{ x^t: \sum_{h=1}^{H} \lambda_h^t y_{km}^t \le y_m^t \quad & m = 1, \ldots \ldots \ldots, M \\ \sum_{h=1}^{H} \lambda_h^t x_{hn}^t \ge x_n^t \quad & n = 1, \ldots \ldots \ldots, N \\ \lambda_h^t \ge 0 \quad & h = 1, \ldots \ldots \ldots, H \Bigg\} \end{aligned}$$

The constraint λ_h^t>0 signifies constant returns to scale (CRS). We define $D_o^t(\mathbf{x}^t, \mathbf{y}^t)$as Shephard's distance function at period t with an assumption of strong feasibility of inputs and outputs as:

$$D_o^t(\mathbf{x}^t, \mathbf{y}^t) = \min\{\lambda: (y^t/\lambda) \in P^t(x^t)\}$$

where $D_o^t(\mathbf{x}^t, \mathbf{y}^t)$is the output distance function which denotes the maximum possible expansion of output using the same level of input. The value of output distance function is defined between zero and one and a value of one signifies hundred percent efficiency and that output falls on the boundary of feasible production set. The Malmquist productivity index (M_o) gives us a utilitarian way of decomposing TFP change into technical change (TC) and technical efficiency change (EC). The technical efficiency can be further broken down into pure technical efficiency and scale efficiency. In order to measure the Malmquist productivity index from period t to t+1, we require a few additional distance functions:

$$D_o^t(\mathbf{x}^{t+1}, \mathbf{y}^{t+1}) = \min\{\lambda : (y^{t+1}/\lambda) \in P^t(x^{t+1})\}$$

$$D_o^{t+1}(\mathbf{x}^{t}, \mathbf{y}^{t}) = \min\{\lambda : (y^{t}/\lambda) \in P^{t+1}(x^{t})\}$$

$$D_o^{t+1}(\mathbf{x}^{t+1}, \mathbf{y}^{t+1}) = \min\{\lambda : (y^{t}/\lambda) \in P^{t+1}(x^{t+1})\}$$

The expression $D_o^t(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})$ denotes the multi-period distance function, which indicates the technical efficiency measure using the dataset at period t+1 relative to the best practice frontier at period t, and $D_o^{t+1}(\mathbf{x}^{t}, \mathbf{y}^{t})$signifies the technical efficiency for the data at period t relative to the frontier at period t+1. The M_o is derived from the above four output distance functions to avoid choice of a random base period and the multiplicative mean of indices is taken to form:

$$\text{Mo} = \left[\frac{D_o^{t+1}(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})}{D_o^{t+1}(\mathbf{x}^{t}, \mathbf{y}^{t})} \times \frac{D_o^{t}(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})}{D_o^{t}(\mathbf{x}^{t}, \mathbf{y}^{t})}\right]^{0.5}$$

Total Factor Productivity can be decomposed into two constituents - technological change and technical efficiency. The technological change is an outcome of adoption of new and modern technology in the production process whereas efficiency change is an outcome of efficient use of factors of production and technology. Hence, the MPI index enables us to figure out which decision making units (DMU) improved productivity by catch-up effect i.e. moving closer to the frontier (technical efficiency) and which DMUs by outward movement of their frontier (technological change).

Data Sources

The study period has been bifurcated into two sub-periods, first from 2003-04 to 2007-08 and then from 2008-09 to 2017-18. The first period corresponds to a period before the GFC period and the second period represents the post crisis period. Data for industries has been retrieved from Annual Survey of Industries (ASI) which is published by the Central Statistical Organization (CSO) of India and EPW Research Foundation India time series for input and output variables. The ASI published data only for registered industries. Productivity change and its constituents - Technical change and efficiency change, have been measured for 18 major states of India over the period of 2003-2004 to 2017-2018. These 18 states represent about 87.5% of manufacturing GDP and 92% of manufacturing employment, and are henceforth representative of entire nation. The state of Telangana was carved out in 2014 from the state of Andhra Pradesh. It has been treated as a part of Andhra Pradesh to maintain uniformity in comparison.

Inputs & Outputs

Labour

Two input variables have been considered for this study - labour and capital. Labour is classified in this study as the total persons engaged. The ASI presents before us different metrics for measurement of labour input - First, total person engaged, which represents the total persons engaged in the industry either directly or indirectly involved in the manufacturing process, as paid or unpaid members. Second, the number of employees, which is measured by including all employees - regular, administrative and clerical staff. Third, number of workers, which includes only persons directly involved in manufacturing process. The ASI also provides year-wise data on man-days of work. In this analysis, the measure of total persons engaged was chosen (Kumar, 2006; Sehgal & Sharma, 2012) as it is more representative of all persons involved in the production process.

Capital

As there is no published data on the state-wise capital stock by a government source, different studies use different methods and each has its sets of benefits and limitations. Some studies have used book value of fixed asset as a measure of capital stock (Kumar, 2006; Ray, 2002)Others have chosen Perpetual Inventory Method (PIM) which requires an estimate of capital stock in benchmark year and investment in subsequent years. Kumar and Managi (2012) study has used GFCF data extrapolated from the Lakhchaura (2004) study and has assumed the same depreciation rate for all the states which appears problematic. “Flow measure may be questioned on the grounds that depreciation charges in financial accounts may be unrelated to actual depreciation of hardware” (Kumar, 2006). Hence, using the same methodology as used by Ray, 2002; Sehgal & Sharma, 2012; Kathuria et al., 2012, I have decided to use gross fixed capital deflated by a suitable deflator as a measure of capital.

Output

For this study, the output variable we used was gross value added (GVA) at constant prices. GVA allows analysis among industries that deploy heterogeneous raw materials. It also allows us to share the productivity gains between the two intrinsic factors of production - labour and capital without involving external factors like raw materials.

WPI

Since data on interstate variation in prices of manufacturing products and capital is not available,

we fall back on the all-India figures of wholesale price indices (WPI), by taking 2004-05 as the base year, in the form of default deflator for all states. The nominal value of gross output in this study has been deflated by utilising the wholesale price index (WPI) for manufacturing products. For deflating capital, a composite indicator of the wholesale price index of machinery and transport equipment has been devised based on its weight in the input calculation.

Findings and Discussion

Findings for this study have been drawn from the nonparametric analysis of the Malmquist Productivity Index and it is summarized in Tables 1 and 2. It shows the average annual rates of productivity growth separately for the pre- and post-crisis years for each state.A summary of the average performance of all states has been presented instead of year wise disaggregated results for easier analysis. Also, the measures of technical efficiency, technological change and TFP capture the performance relative to the best practice frontier.

For the pre-crisis period, Indian manufacturing productivity grew at the rate of 2.3% per year. There was a substantial deceleration in the rate of growth to 1.2% per year during the post-crisis years. This is an important finding and is crucial evidence that the crisis did have an impact on the productivity of the Indian economy. This finding is in line with other estimators as discussed earlier. There was an increase in average capital output ratio of 21% from pre-crisis to post-crisis period. It further suggests the ineffectiveness of the capital investment and points towards decline in total factor productivity in the post GFC period.

Few other similar studies have also directed towards a fall in productivity in the post crisis period. According to the KLEMS framework based methodology, TFP growth declined in the post-crisis period from 2.7% to 2.3% from 2000-07 to 2008-2015 respectively (RBI, 2018). My inferences are slightly different from those of KLEMS studies on account of variation in selection of inputs and outputs and the overall methodology used. The primal factor to focus here is that directionally, both these studies, focus towards a reduction in total factor productivity in the post crisis period.

Table 1: Pre-crisis Period : 2003-04 to 2007-08

State	effch	techch	pech	sech	tfpch
Maharashtra	0.938	1.047	1.014	0.925	0.982
Gujarat	0.979	1.129	1.036	0.945	1.105
Tamil Nadu	0.891	1.118	1.000	0.891	0.996
Karnataka	1.079	1.061	1.160	0.930	1.145
Andhra Pradesh	0.908	1.132	1.000	0.908	1.028
Uttar Pradesh	0.903	1.111	1.061	0.851	1.003
Haryana	0.992	1.053	1.090	0.910	1.044
Jharkhand	0.869	1.053	0.943	0.922	0.916
West Bengal	0.922	1.179	1.086	0.849	1.087
Chhattisgarh	0.961	1.102	1.028	0.935	1.059
Punjab	0.936	1.055	0.995	0.941	0.988
Madhya Pradesh	0.688	1.275	0.875	0.786	0.877
Rajasthan	0.879	1.093	0.998	0.881	0.961
Kerala	1.000	1.037	1.000	1.000	1.037
Odisha	1.052	1.076	1.114	0.944	1.132
Bihar	0.748	1.120	0.919	0.814	0.838
Uttaranchal	1.072	1.045	1.128	0.950	1.120
Himachal Pradesh	1.117	1.053	1.110	1.006	1.176
Average	0.934	1.095	1.028	0.909	1.023

Source: Author’s Calculations

For table 1 and 2, the values in column effch signify average annual changes in the efficiency level over time for every state, and a value more than unity for this metric implies that a state witnessed improvement in technical efficiency over the study period. In the same way, an entry with value more (less) than unity in column techch shows technological progress (regress) over the time. During the entire period from 2003-04 to 2017-18, the bulk of the Indian states in our study witnessed positive TFPG, and for majority of the states the growth rate decelerated during the post-crisis period when compared with pre-crisis period. In the sample period of 2003-2004 to 2017-2018, 11 out of 18 states experienced productivity decline.

Table 2: Post-crisis Period : 2008-09 to 2017-18

State	effch	techch	pech	sech	tfpch
Maharashtra	1.035	0.986	1.022	1.013	1.021
Gujarat	1.041	0.974	1.033	1.008	1.014
Tamil Nadu	0.940	1.089	0.942	0.998	1.024
Karnataka	1.044	0.948	1.035	1.009	0.990
Andhra Pradesh	0.976	1.059	0.984	0.992	1.034
Uttar Pradesh	1.051	0.956	1.039	1.012	1.005
Haryana	0.999	0.985	1.007	0.992	0.984
Jharkhand	1.058	0.978	1.035	1.022	1.034
West Bengal	0.989	1.066	0.994	0.995	1.054
Chhattisgarh	1.085	0.960	1.072	1.012	1.041
Punjab	0.967	0.973	0.982	0.985	0.941
Madhya Pradesh	1.018	0.965	1.049	0.970	0.982
Rajasthan	1.049	0.952	1.041	1.008	0.999
Kerala	0.989	1.023	1.000	0.989	1.012
Odisha	0.984	1.047	0.983	1.001	1.030
Bihar	0.994	0.983	0.984	1.010	0.977
Uttaranchal	1.086	0.953	1.015	1.070	1.035
Himachal Pradesh	1.055	0.985	0.987	1.069	1.039
Average	1.019	0.993	1.011	1.008	1.012

Source: Author's calculations

During 2003-04 to 2007-08, 11 states experienced positive growth in TFP. Prominent among them were Gujarat, Tamil Nadu, Kerala, Odisha and Himachal. 10 out of the 18 states had a higher than average productivity of 1.023. During the post crisis period 2008-09 to 2017-18, 12 states had a positive growth in TFP even though the average value of TFP declined. West Bengal, Andhra Pradesh, Jharkhand and Chhattisgarh experienced the highest productivity growth. Since the productivity declined in the post crisis period, 11 states experienced above average productivity growth.

Maharashtra and Tamil Nadu showed significant improvement when they switched from productivity decline path to productivity growth path post the crisis. On the other hand, Karnataka and Haryana displayed contrasting behaviour and total factor productivity turned negative for these states post crisis. Surprisingly, some of the lagging industrial states like Himachal Pradesh and Odisha displayed much faster productivity growth post the crisis as compared to Maharashtra and Tamil Nadu, the traditionally dominant industrial states. For West Bengal, Chhattisgarh, Kerala, Punjab and Uttaranchal productivity growth continued post crisis but growth rate was lower than before. Hence, the overall analysis from a pre- and post-crisis years comparison of growth of manufacturing productivity shows a decline in productivity at the regional and national levels.

Analysis of Tables 1 and 2 shows that at the national level, productivity growth was predominantly led by technological progress before the crisis, while technical efficiency changes propelled growth during the post crisis period. Hence, during the pre-crisis era, use of superior technology pushed the Indian manufacturing firms to be on a higher growth path whereas they were able to attain better utilization of factors of production post crisis. This is again corroborated by significant fall in technological progress and rise in efficiency during the study period. During pre-crisis, all the states witnessed technological progress, while most of the states showed decline in technical efficiency. Karnataka, Himachal, Uttaranchal, Odisha and Kerala were the only states that showed an increase in technical efficiency during this period. Scale efficiency decreased in all states apart from Kerala and Himachal Pradesh.

Over the post-crisis years most states showed technological regress along with improvements in technical efficiency. High income states like Maharashtra, Gujarat, Karnataka witnessed a catching up effect and moved closer to the frontier. Both scale and pure technical efficiency increased for the majority of the states. Kerala was the only state that was efficient in both periods on the VRS frontier indicating an efficiency score of 1 and proper utilization of resources. The average increment was 1.9% in technical efficiency in the post-crisis period as compared to a 6.6% decline in pre-crisis period. On the other hand, technological progress saw a opposite trend with depreciation at 0.7% in the post-crisis period. If we further break down the efficiency numbers, we see that most of the increment was on account of jump in the scale efficiency and pure technical efficiency in fact declined.

Comparison with Parametric method

In the growth accounting paradigm, total factor productivity growth is analogous to technical change and the fact that that productivity growth always signifies technological progress. (Kumar, 2004) However, in this study we have seen quite the opposite. For Indian manufacturing, we observe productivity growth even at the time of presence of technological regress. For Gujarat, we observe that even though the state was witnessing technological regress, it still displayed productivity growth driven primarily by advancement in technical efficiency and scale efficiency in the post-crisis period. There is also an example of decline in productivity in the presence of technological progress. In the pre-crisis period, Rajasthan experienced technological progress but witnessed productivity decline due to poor technical efficiency. This is one of the primary reasons why the non-parametric methods have been used to study productivity growth.

We also estimated Total Factor Productivity growth measures for every state using the Translog Index method of growth accounting framework. To calculate the TFP growth using growth accounting exercise, we require information on the inputs and outputs, and on the inputs share of output. We have calculated the share of labour by dividing the total real emoluments by the gross value added for every state. As we saw with Malmquist Productivity Index approach, the productivity growth has declined in the post-crisis period. However, the correlation coefficient between the two measures of productivity, MPI and growth accounting, is not significant at the interval of different time periods. Given that the same data has been used for estimating the TFP growth, we need to ascertain why the results of two methods differ. In the growth accounting approach using the factor shares of outputs, the absence of allocation efficiency is assumed. For growth accounting approach, every state has been compared to only itself in the last year, and not to a best practices benchmark as in the case of non-parametric MPI. This might be a possible reason for the deviation in the observed inferences.

Our estimates of state level productivities display a noticeable variation. We have used coefficient of variation to measure the changes in total factor productivity across all states in our study both before and after the crisis. We observe that the inter-state variation in productivities has diminished during the post-crisis years reflecting convergence in productivity growth experience. The value of coefficient of variation has reduced from 0.008 to 0.0008 from the pre to post crisis period. This is in accordance with the convergence hypothesis of economic growth which postulates that the productivity in lower-income countries is bound to converge towards that of high-income countries. “While national policies and behaviour patterns do substantially affect productivity growth, the spillover from leader economies to followers is large.” (Baumol, 1986).

The TFPG analysis gives us an opportunity to figure out if creation of new states from larger states leads to enhancement in productivity or not. As a part of administrative reorganization, three new states namely – Chhattisgarh, Jharkhand and Uttaranchal were created reconstituting Madhya Pradesh, Bihar and Uttar Pradesh in the year 2001. One of the primary reasons for creation of two out of the three new states was economic backwardness in the states despite opulence of natural resources. “It was argued that creation of the new states would lead to better governance, effective resource utilization and would help to meet the developmental aspiration of the marginalized segments in those states” (Misra, 2019).

We can use this analysis to compare the TFP growth for the new created states against that of the parent states. We find that in the initial years of bifurcation, i.e. during 2003-2008, the new states performed much better than their parent states on account of higher productivity - Chhattisgarh (1.059) vs Madhya Pradesh (0.877), Bihar (0.83) vs Jharkhand (0.916) and Uttaranchal (1.12) vs Uttar Pradesh (1.003). The same pattern was repeated during 2009-2017 with Chhattisgarh (1.041) vs Madhya Pradesh (0.982), Bihar (0.977) vs Jharkhand (1.034) and Uttaranchal(1.035) vs Uttar Pradesh(1.005). In the pre-crisis period, we notice that even though the technological progress is much lesser for all three new states, they trump their parent states on the back of high technical efficiency gains. Since their creation, these states have seen massive improvements in per capita income and overall economic growth as well. This provides evidence to support the argument that utilization of natural and financial resources can be more effective in a smaller administrative unit. This is further supported by Anjali (2014), which shows that new states have done a better job than their parent states in providing quality health and education facilities to its citizens.

Determinants of TFPG

Productivity is a long-term propeller of economic prosperity, standard of living and the degree of competitiveness of a country. Therefore, it is imperative to figure out the factors which can enhance the productivity growth of Indian states. Nagraj et al. (2000) found that infrastructure – both physical and social, played a vital role in propelling growth trajectory of the state. Khanna and Sharma (2021) show that 1%rise in the aggregate infrastructure stock lead to a 0.16% growth in productivity growth. Hence, to find the relationship between MPI and its determinants, we have chosen the following variables - Education Index (EI) of the Human Development Index (HDI) composed of Mean years of Schooling and Adult Literacy rate, Health Index (HI) of HDI composed of life expectancy, Per capita installed Electricity (EL), Road density (RD) in the state and telecommunication index (TI). The Education and Health index act as indicators of social infrastructure whereas RD, EL and TI represent the physical infrastructure. The regression equation is represented by:

$$Ln(TP) = \beta_0 + \beta_1 Ln(TP_{-1}) + \beta_2 Ln(EI) + \beta_3 Ln(HI) + \beta_4 Ln(EL) + \beta_5 Ln(RD) + \beta_6 Ln(TI) + \varepsilon$$

Table 3: Determinants of Productivity

Variable	Coefficients	P-value	Significance
Intercept	-0.407	0.064	10%
TP-1	-1.219	0.011	5%
EI	0.260	0.038	5%
HI	0.181	0.055	10%
EL	0.025	0.075	10%
RD	0.020	0.045	5%
TI	0.210	0.432	Insignificant
Rho Squared	0.714		

The results are displayed in table 3. We see a healthy rho squared value of 0.714 signifying that TFP is dependent on infrastructure in the state. TP_{-1}here refers to the total factor productivity in the preceding year. A negative coefficient for the TP_{-1} variable was witnessed which supports our theory of convergence. The coefficients for both education and health are positive and significant. But the coefficient for education is higher indicating that a 1% increase in education index leads to a 0.26% increase in the TFP. This shows that the state's investment in education and health infrastructure like building schools & hospitals; training teachers, doctors, and nurses has a major impact on the development of human capital.

Electricity and road density have a positive coefficient as well and reaffirm that investment in infrastructure is essential for the development of the industrial sector. Improved road density leads to better connectivity and brings down transaction costs and facilitates faster movement of goods. For example: Gujrat, which is one of the fastest industrialising state in India, has the highest road density in the country, with almost 92 per cent of them paved compared to a national average of just 58% (DFID, 2010).Similarly, increase in installed electricity capacity in a state leads to increased economic activity. It ensures higher manhours at work and promotes adoption of mechanisation and automation of a lot of industrial processes ensuring higher productivity.

The coefficient for telecommunication index was found to be statistically insignificant. Similar results were seen by Sridhar and Sridhar (2014) where they show that the impact of telecom penetration on total output is much lower for developing countries than that reported for OECD countries, contradicting the convergence hypothesis. Our belief was that cell phone penetration in the country can massively reduce the transaction costs related to the production of goods and services. One of the major reasons for insignificant relationship could be due to the technology obsolescence in the telecommunication network and high costs. As a result, even though the penetration might be high, the usage or utilisation may be not reflect the same.

Conclusion

This study aims to estimate the components of total factor productivity in organized manufacturing for the Indian states from a period of 2003-04 to 2017-18. The non-parametric Malmquist Productivity index was chosen as the primary method of analysis and decomposed it into technological change and technical efficiency. Very few studies have attempted this approach at state level for the post crisis period (2009-2017) and our work is a step in that direction.

We found that productivity growth for India declined from 2.3% during 2003-2008 to 1.2% in the post crisis period, namely, 2009-2017 indicating that the global financial crisis had a definitive impact on Indian manufacturing. In the pre-crisis period, most of the growth in total factor productivity was driven by technological change whereas in the post-crisis period, this growth was driven by rise in technical efficiency. Adoption of new and advanced technology in the production process led to productivity growth in the pre-crisis period, however, better utilization of resources led to higher productivity in the post-crisis period. In a period when the global demand had plummeted and domestic consumption was on a decline, the firms invested more resources and energy in better utilization rather than buying new technology.

The states of Maharashtra and Tamil Nadu showed tremendous improvement and changed their trajectory from productivity decline to productivity growth after the crisis. On the other hand, total factor productivity growth for Karnataka and Haryana turned negative post crisis.We further see the new states of Jharkhand, Chhattisgarh and Uttarakhand have performed better than their parent states signifying that creation of smaller regions has led to better administrative results and higher productivity. Variation among the states is also decreasing with time and this supports the convergence theory of economic development.

We find that productivity depends strongly on the education and health index. Other components of infrastructure like road density and installed electricity per capita also had a positive impact on productivity of the state. On comparison of our results with the growth accounting framework we do not see any significant relationship between the two. The methodologies are very different in that respect but directionally pointed towards declining TFP in the post crisis period.

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