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Abstract

Total factor productivity plays an important role in the growth of the economy. Using recently available state level data over 1993 and 2005, we find widespread regional variation in productivity changes. In the beginning of the liberalization era, improvement in technical efficiency contributes to the growth of the productivity. In the later periods, however, the productivity growth is governed by the growth in technical progress. We also study about convergence in state level and find a tendency of convergence in productivity growth though only states that are efficient remain on the production frontier.

Keywords: India, Total factor productivity, Nonparametric analysis, Convergence

JEL Classification: O40, O53, E19

1. Introduction

India introduced the new economic policy in 1991 to bring major changes in the economy's structure and policy regime. One of the major objectives of the new economic policy was to improve the productive efficiency of the economy. Previous analyses measuring the effect of economic reforms on the economic performance have largely been confined either to the economy as a whole (e.g., Bosworth et al., 2007) or to individual sectors (e.g., Goldar (2004) for manufacturing sector). In the literature, some attempts have been made by explicitly analyzing the regional growth (e.g., Ahluwalia, 2000; Sachs et al., 2002). However, there are good reasons why such an analysis that measures growth in total factor productivity (TFP) at the state level should be of special interest. This is because balanced regional development has always been one of the major objectives of national policy in India. One striking fact in the post reform growth of India is that there has been significant increase in regional disparities of growth and poverty reduction across states (Rao, 2008). State-wise, nearly 72% of India's poor and half of the population are located in the following six states: Uttar Pradesh (including Uttaranchal), Bihar (including Jharkhand), Madhya Pradesh (including Chhattisgarh), Maharashtra, West Bengal and Orissa. Economic liberalization reduces the role of central government in reducing regional imbalance through controls and regulations, and enhances interstate competition. Gains from competitive federalism are linked to the competitive strength of competing jurisdictions (Breton, 1996).

The purpose of this paper is to provide empirical evidence concerning pattern of TFP growth using the Malmquist productivity index and its components for the Indian states during the liberalization era. We use linear programming approach rather than econometric or growth accounting framework for measuring TFP. The advantage of this approach is that it allows decomposition of TFP changes into technical changes (TC) and efficiency changes (EC). As technical- and efficiency changes are analogous to the notions of technological innovation and adoption respectively, the dynamics of the recent growth observed in the Indian states can be appreciated better. Moreover, there is no need to assume the absence of technical and allocative inefficiency in production in practice.

In measuring the annual rates of change in productivity and technical efficiency in the individual states in India, we use data for the period 1993-1994 to 2004-2005.[1] Results of this study show that, on average, the annual rate of productivity growth has been improving over the period of time during the sample years. We can also point out that some states have actually experienced a slowdown or even productivity decline during the liberalization era. The paper also analyzes the determinants of TFP. It investigates the causes of productivity divergence among the states in the light of convergence and divergence hypotheses. It unveils that the productivity differences in the states can be explained in terms of policies and institutions which help in increasing the level of human development index. It is also observed that the growth of TFP at state level is positively associated with the degree to which a state has been embracing the economic reforms.

The paper is organized as follows: We begin with a literature review and our research strategy in Section 2. The linear programming technique and Malmquist productivity index are described in Section 3. Section 4 describes the data used in the study and discusses the productivity experience of the states during the period of 1993-1994 to 2004-2005. Some concluding remarks are given in the final section of the paper.

2. Economic Growth and Productivity: Background

Several issues related to the regional economic disparities in India received recent attention. Most of these issues are related to or motivated by the variability and volatility in growth rates experienced by the Indian states. Productivity analysis helps to understand the level of economic prosperity, standard of living and the degree of competitiveness of a country or a region. Therefore, it is important to find which factors determine productivity growth in the Indian states.

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[1] Annual data in India is reported for fiscal rather than calendar years. The fiscal year begins on April 1 and ends on March 31 of the following year

2.1 Neoclassical Growth Theory

There are various theories that explain productivity growth in countries, where our particular interests are the neoclassical- and the endogenous growth theories. The neoclassical growth theories found their genesis in the work of Solow (1956). The marginal product of capital is low in high income countries as these countries exhibit a high capital labor ratio, and it is high in the developing countries where the capital labor ratio is low. The difference in the marginal product of capital are supposed to cause the high growth rate of income in developing countries relative to developed countries (Evans and Karras, 1996) and this phenomenon is known as convergence hypothesis in the economic growth literature. The convergence hypothesis states that productivity in low-income countries tends to converge towards those of high income countries, (Baumol, 1986; Baumol et al., 1989). The essence of the convergence hypothesis lies in the diminishing returns to capital.

Much of the growth regression literature is motivated by this convergence hypothesis (Barro, 1991; Barro and Sala-i-Martin, 1992). Barro et al. (1995) find the presence of convergence independent of the sources of capital - whether it is generated by the domestic savings or flows in from abroad. It also finds support in the growth accounting exercises (e.g., Young, 1995). Though the convergence hypothesis is able to explain the growth phenomenon of OCED countries to some extent, it could not explain the differences observed in the growth path of most of the developing countries.

2.2 Endogenous Growth Theory

On the other hand, the endogenous growth theories are originated from the work of Arrow (1962) and further developed by Lucas (1988) and Romer (1990). They state that the difference in productivity between developed and developing countries remains constant or even diverges over time. The essence lies in the concept of economies of scale that are generated from externalities associated with the acquisition of technical knowledge. The accumulation of knowledge contributes to increased productivity at the aggregate level even though the individual firms face diminishing returns to capital. Thus, according to the endogenous growth theories the diminishing returns to scale disappears and the growth path of developing economies diverges from the developed countries.

However, these endogenous growth theories also explain the phenomenon of convergence in terms of the effect of technological catch-up. It is hypothesized that imitations are less costly than innovations (i.e., initially poor countries, which are below the world technology frontier, experience faster improvement in technology than the leaders) (Howitt, 2000). Empirical evidence on income differences across countries largely due to differences in TFP across countries is consistent with this hypothesis (e.g., Klenow and Rodriguez-Clare, 1997; Hall and Jones, 1999).

2.3 Growth in India

In the category of fastest growing economies are included neither highest nor lowest per capita income countries; some countries has grown faster than most of the high income countries (e.g., South Korea). But it is also true that the growth rate of some of the poor countries has either stagnated or declined (e.g., African countries). The phenomenon is visible within India also. Krishana (2004) reports that the middle income states such as Tamil Nadu, Karnataka, West Bengal and Kerala fared better than the high income states such as Punjab and Haryana during the 1990s. These two states suffered marked deceleration whereas the other two high income states (Gujarat and Maharashtra) have shown improvement in their performance. In some of the middle and low income states, growth rate decelerated. Andhra Pradesh (middle income), Bihar and Uttar Pradesh (low income states) experienced decline in growth rate in the liberalization era.

Ghosh et al. (1998), using data for 26 Indian states over the period of 1960-1961 to 1994-1995, attempted to test the hypothesis of absolute convergence and found evidence for strong divergence. Similarly, Rao et al. (1999) use data for the 14 major states over the period of 1964-1965 to 1994-1995 and show the evidence in favor of economic divergence. They find that the possible reasons for divergence are the skewed distribution of public expenditure attracting larger flows of investment to better off states in the country and the economies of scale to capital. However, Nagraj et al. (2000) apply panel data for 17 countries for the years 1960-1994 and find evidence in favor of conditional convergence. Thus, the review of various Indian studies finds that the evidences on regional convergence or divergence are inconclusive.

2.4 Determinants of Growth

Institutions and public policies determine the development process of a country (Olson, 1996). Hall and Jones (1999) explain differences in labor productivity across countries in terms of differences in institutions and government polices, which they call social infrastructure. In a recent theoretical analysis, Acemoglu et al. (2006) find that, at the early stages of development, anti-competition public policies targeted towards increasing investments and adoption of existing technologies may be beneficial. But, as the economies approaches towards technology frontiers, the economies are required to abandon anti-competition policies and embrace 'appropriate' institutions that encourage competition and innovations so that the economies will not end up in a non convergence trap.

In the Indian context, Sachs et al. (2002) find, that except the state of Andhra Pradesh, the states that embraced economic reforms are the fastest growing states in the liberalization era. Rao et al. (1999) find that the possible major determinant of the growth of a state is the level of private investment in the state. The level of private investment depends on the availability of incentive structure in a country or region. Nagraj et al. (2000) find physical and social infrastructure as the factors that play major role in determining the growth path of a state.

2.5 Our Empirical Strategy

We apply mathematical programming techniques to construct Malmquist productivity indices for the major Indian states during the liberalization era. The Malmquist index uses distance functions, which can be calculated by exploiting their relationship to the Ferrell technical efficiency measures. Our analysis is confined to the measurement of TFP growth in the major states of India, which is decomposed into efficiency and technological changes. Färe et al. (1994) shows that this measure of TFP is equivalent to

Solowian measure of TFP. Solow (1956) consider TFP as the residue of difference between the growth rate of outputs and the growth rates of inputs, and this process is termed as growth accounting exercise. In the growth accounting framework, it is assumed that observed output is equivalent to the frontier output. TFP index is interpreted as the index of technological change. In the real world, where the economies are often not operating at the frontier and, therefore, the growth accounting framework produces biased estimates of technological change.

Unlike the framework used in the present paper, measuring TFP applying growth accounting assumes that the technological changes are Hicks-neutral and the factors of production are paid according to their marginal product, i.e., absence of allocation inefficiency. Note that the TFP being obtained as residual, crucially depends on the validity of assumptions and the quality of data. In developing countries, capital input data quality is generally not satisfactory. Moreover, in India, data on factors shares are not available that are required in the growth accounting framework. In the absence of factor share data, one can estimate these shares using aggregate production function, which is subject to specific functional form bias and the problem becomes exaggerated for India. This is because there is a dominant role of self employed in total employment. The earnings of self employed enter into national accounts as mixed factor income reflecting the combined income of both labor and capital. Mixed income accounts for about 45 percent of the national income and 79 percent of the income of the unorganized sector in 2002-2003 (Bosworth et al., 2007).

3. Measurement of Total Factor Productivity

To measure TFP at state level, we apply non-parametric linear programming (LP). The LP approach has two advantages over the econometric method in measuring productivity change (see Grosskopf, 1986). First, it compares the states to the 'best' practice technology rather than 'average' practice technology as in econometric studies. Second, it does not require the specification of an *ad hoc* functional form or error structure. In the process, the LP approach allows the recovery of various efficiency and productivity measures in an easily calculable manner. Specifically, it is able to answer questions related to technical efficiency and productivity change.

We employ output distance function to construct the various measures of efficiency and productivity, which allows estimation of a multiple output, multiple input production technology. It provides the maximum proportional expansion of all outputs that still allows a state to use a given level of inputs. It is the reciprocal of output based Farrell measure of technical efficiency and provides the theoretical basis for the Malmquist productivity index.

Let $\mathbf{x}^t = (x_1^t, x_2^t, \ldots, x_N^t)$ denote an input vector at period t with i=1,2,…,N inputs and $\mathbf{y}^t = (y_1^t, y_2^t, \ldots y_M^t)$ an output vector at period t with j=1,2,…,M where $\mathbf{x}^t \in \Re_+^N$ and $\mathbf{y}^t \in \Re_+^M$. The technology can be represented by the output possibility set as follows:

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

where $S^t = \{(\mathbf{x}^t, \mathbf{y}^t) : \mathbf{x}^t \text{ can produce } \mathbf{y}^t\}$ is the technology set at period t. The output possibility set provides all the feasible output sets that can be feasible with the given input bundle. The output distance function requires information on input and output quantity and is independent of input and output prices as well as behavioral assumptions on producers.

Let there be k=1,2,…..,K^t states that produce M outputs $y_m^{k,t}, m = 1, \ldots, M$ using N inputs $x_n^{k,t}, n = 1, \ldots, N$, at each time period t=1,….,T. A piecewise linear requirement set at period t is defined as:

$$\begin{aligned} P^t(y^t) = \{x^t : \sum_{k=1}^{K} z_k^t y_{km}^t \le y_m^t \qquad & m = 1, \ldots, M \\ \sum_{k=1}^{K} z_k^t x_{kn}^t \ge x_n^t \qquad & n = 1, \ldots, N \\ z_k^t \ge 0 \qquad & k = 1, \ldots, K\} \end{aligned} \tag{2}$$

where z_k^t indicates intensity level, which makes the activity of each observation expand or contract to construct a piecewise linear technology (Färe, Grosskof and Lovell, 1994). The constraint z_k^t >0 implies constant returns to scale (CRS). Let us define $D_o^t(\mathbf{x}^t, \mathbf{y}^t)$ as Shephard's output distance function at period t with strong disposability of inputs and outputs assumption as:

$$D_o^t(\mathbf{x}^t, \mathbf{y}^t) = \min\{\lambda : (y^t / \lambda) \in P^t(x^t)\} \tag{3}$$

where $D_o^t(\mathbf{x}^t, \mathbf{y}^t)$ estimates the maximum possible expansion of y^t and can be termed as a measure of technical efficiency (TE). The value of output distance function lies between zero and one. If $D_o^t(x^t, y^t) = 1$; the state can be regarded as 100 percent efficient and y is on the boundary of feasible production set. For $D_o(x, y) \leq 1$; y is in the interior of feasible production set and could be characterized as 100×D_o percent efficient.

The Malmquist productivity index (MALM) yields a convenient way of decomposing TFP change into technical change (TC) and technical efficiency change (EC). In order to estimate the Malmquist productivity index from period t to t+1, additional distance functions required are:

$$D_o^t(\mathbf{x}^{t+1}, \mathbf{y}^{t+1}) = \min\{\lambda : (y^{t+1} / \lambda) \in P^t(x^{t+1})\} \tag{4}$$

$$D_o^{t+1}(\mathbf{x}^t, \mathbf{y}^t) = \min\{\lambda : (y^t / \lambda) \in P^{t+1}(x^t)\} \tag{5}$$

and

$$D_o^{t+1}(\mathbf{x}^{t+1}, \mathbf{y}^{t+1}) = \min\{\lambda : (y^{t+1} / \lambda) \in P^{t+1}(x^{t+1})\} \tag{6}$$

The cross period distance function, $D_o^t(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})$, indicates the efficiency measure using the observation at period t+1 relative to the frontier technology at period t, and

$D_o^{t+1}(\mathbf{x}^t, \mathbf{y}^t)$ shows the efficiency measure employing the observation at period t relative to the frontier technology at period t+1.

The MALM consists of four output distance functions to avoid choosing arbitrary base period and the geometric mean of two output based technical efficiency indices is taken to form:

$$MALM = \left[\frac{D_o^{t+1}(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})}{D_o^{t+1}(\mathbf{x}^t, \mathbf{y}^t)} \times \frac{D_o^t(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})}{D_o^t(\mathbf{x}^t, \mathbf{y}^t)} \right]^{0.5} \tag{7}$$

The MALM can be decomposed into EC and TC as:

$$MALM = \underbrace{\frac{D_o^{t+1}(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})}{D_o^t(\mathbf{x}^t, \mathbf{y}^t)}}_{EC} \underbrace{\left[\frac{D_o^t(\mathbf{x}^t, \mathbf{y}^t)}{D_o^{t+1}(\mathbf{x}^t, \mathbf{y}^t)} \times \frac{D_o^t(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})}{D_o^{t+1}(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})} \right]^{0.5}}_{TC} \tag{8}$$

where the first term defines the changes in efficiency from period t to t+1, i.e., moving closer to the production frontier or 'catching up'. The second term, i.e., the geometric mean (GM) in parentheses, represents changes in technology, i.e., a shift in the frontier from period t to period t+1. All the indices can be interpreted as progress, no change, and regress, when their values are greater than one, equal to one, and less than one respectively.

4. Data and Results

We calculate productivity and its components for 14 major Indian states over the period of 1993-1994 to 2004-2005. The data used in this study for calculating productivity and its various components come mainly from two sources: Central Statistical Organization (CSO) and Census of India. It is modeled that a state is producing gross state domestic product (GSDP) by employing two factor inputs, physical- and human capital. India is a union of 28 states and 7 union territories but our analysis of productivity measurement is confined to only 14 major states.[2] The states of Chhattisgarh, Jharkhand and Uttarakhand were treated as parts of the states from which they were carved out in 2000 (Madhya Pradesh, Bihar and Uttar Pradesh, respectively). These 14 states account for about 84.5 percent of national gross domestic product (GDP), 92 percent of national gross fixed capital formation (GFCF), 93.5 percent of total labor force, and 92.5 percent of human capital in the country in 1999-2000 and are therefore representative.

The data on output as measured GSDP comes from CSO. CSO compiles statistics for GSDP for all the states and union territories in India. We use the series on GSDP comprising period 1993-1994 to 2004-2005 with the base year 1993-1994. CSO compiles statistics on GFCF at the national level but the figures of GFCF are not available at the state level. Earlier studies analyzing pattern and determinants of economic growth of Indian states have used proxies for investment and capital stock. For instance, Rao et al. (1999) consider capital expenditure of state governments as a proxy for public investment and the credit extended by the financial institutions as a substitute for private investment. Here, the implicit assumptions, among other problems, are that the credit is used only for capital formation purposes and state governments do not rely on off-budgetary expenditures for financing infrastructure projects.

Lakhchaura (2004) provides estimates of GFCF at the state level for the period 1993-1994 to 1999-2000. These estimates of GFCF cover public and private fixed capital formation in all major sectors of the state economy, including agriculture. Moreover, these figures include central government investment in railways, communications, banking, central government administration and are dissected by states and union territories. We linearly extrapolate these estimates of GFCF at state level to 2004-2005.[3] Note that Lakhchaura (2004) provides estimates at current prices. We convert nominal values of GFCF into constant 1993-1994 prices series through deflating it by a state level GDP deflator derived from the nominal and real values of GSDP. We use perpetual

[2] The 14 major states are Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal.
[3] Linear interpolation does not affect the results of TFP for the period 1993-1994 to 1999-2000 as we use adjunct years measure of Malmquist index.

inventory method to estimate the capital stock at the state level. Initial values of capital stock are calculated using the methodology developed by Nehru and Dhareshwar (1993) as:

$$K_i = \frac{I_i}{(\delta + g_i)} \tag{9}$$

where I_i denotes the real value of GFCF in the i^{th} state, δ is the national depreciation rate, and g_i is the rate of growth of GFCF in the i^{th} state. Following CSO, we assume a depreciation rate of 7 percent.

We follow Bils and Klenow (2000) to construct the figures of human capital index (H) at state level using the average year of schooling (ε). Labor in efficiency units in state *i* and year *t* is defined as:

$$\hat{L}_{it} = H_{it} L_{it} = \exp^{f(\varepsilon_{it})} L_{it} \tag{10}$$

and

$$f(\varepsilon_{it}) = \frac{\theta}{1-\psi} \varepsilon_{it}^{1-\psi} \tag{11}$$

where L_{it} is the number of workers, $\hat{L}_{it}$ is the amount of labor input measured in *efficiency* units in state *i* at time *t*, and the parameter ψ is the slope of the Mincer earnings function. Bils and Klenow (2000) estimate the value of $\psi=0.58$ and $\theta=0.32$ from a sample of 56 countries that includes India also.

To obtain the estimates of human capital, we require statistics on the total number of workers and average years of schooling at the state level given the parameter values of ψ and θ. *Census of India* reports the number of total workers at the state level. Census in India is conducted at an interval of 10 years. Statistics on the average years of schooling for the employed persons at the state level is not available in India. We compute the average years of schooling for the working age population instead from the Census data of 1991 and 2001. Census data contains the statistics on educational attainment of individuals in the working age of 15-64. The average years of schooling for 1991 and 2001 are computed as the weighted average. Where the weight is the number of individuals in a particular schooling cycle and with respect to schooling cycle, we assume that primary schooling take 5 years, middle level requires 8 years, secondary 10 years, higher secondary 12 years and tertiary education requires 16 years. For the remaining years of sample, average years of schooling are obtained by linear interpolation from the benchmark years of the census.

4.1 Growth Rates of Output and Inputs

Table 1 provides growth rates of GSDP, physical and human capital for all the major 14 states. The last row in the table provides the weighted state averages, where the weight is the relative share of each of the state in national GDP in 1993-1994. We divide the sample period into three sub-periods, 1993-1994 to 1996-1997, 1997-1998 to 2002-2003 and 2003-2004 to 2004-2005. We also divide the sample states in three categories: low income states (Bihar, Orissa, Rajasthan, Madhya Pradesh and Uttar Pradesh), middle income states (Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and West Bengal) and high income states (Gujarat, Haryana, Maharashtra and Punjab). During the first sub period the Indian economy grew at 6.41 percent per year, but during the second sub period there was some loss to the growth momentum. The second sub period also coincides with the onset of the East Asian financial crisis coupled with the domestic set backs such as slow down in agricultural growth caused by the lower than normal monsoon and some slacking in the pace of economic reforms (Mohan, 2008). Since 2003-2004 the growth momentum has again been picked up, and the average growth rate of sample states was 7.35 percent per year in the third sample sub period. During the period of 1993-1994 to 1999-2000, the growth rate of physical capital was 5.82 percent and of human capital was 3.62 percent per year. A cursory look on the growth rates of GSDP across states finds the presence of strong variability and volatility cross states. During the first sub period the observed growth rate of GSDP was below two percent per year in Orissa whereas it was as high as about 12 percent for the state of Gujarat. Even among the low income states, Rajasthan experienced the growth rate of more than 10 percent during this period. During the second sub period, we observe relatively less variability in growth rate across states, but it again starts to increase with the pickup in growth momentum in 2003-2004. In the third sub period, Bihar had a low growth rate of only 2.5 percent per year.

During the period of 1993-1994 to 1999-2000, the weighted average of growth of physical capital across Indian states was about six percent per year, but there is again a strong variability across states. In the state of Orissa, the stock of physical capital declined at a rate of about one percent per year, but the states of Karnataka (middle income) and Gujarat (high income) experienced growth in physical capital of the magnitude of about 12 percent per year. As far human capital is concerned, the growth rate was lowest in the states of Kerala and Tamil Nadu since in these two states literacy rate is quite high and the growth rate of population is much lower relative to other states even at the beginning of sample years.

4.2 Changes in Total Factor Productivity

Since the basic components of Malmquist index is related to measures of technical efficiency, we first report these results. Values of unity imply that the state is on the production frontier in the associated year while those exceeding unity imply that it is below the frontier, i.e., technically inefficient. The state-wise results of technical efficiency are presented in Table 2. Punjab, which is a high income state, is consistently efficient. It is on the production frontier in all the sample years. Table 2 also reveals that the high and middle income states, except Andhra Pradesh and Karnataka, are moving towards the frontier over the period of time. Andhra Pradesh shows efficiency improvement during the period of 1997-1998 to 2002-2003 over 1993-1994 to 1996-1997, but the inefficiency increased during the period 2003-2004 to 2004-2005. Karnataka experienced the decline in the level of efficiency over the period of time. In the low income states, though Orissa is the least efficient state among the sample states, but the level of efficiency has been improving over the period of time. Uttar Pradesh, another low income state, which is on the frontier during the sample period 1993-1994 to 1996-1997, is getting away from the frontier in the later years. Similarly, the inefficiency has increased in Madhya Pradesh. Bihar and Rajasthan are observing downward and then upward trends in technical inefficiency. Variation in technical efficiency across states measured by the standard deviation over the period of time has been decreasing implying that the average level of inefficiency (wastage) is declining in the liberalization era in Indian economy (see Figure 1).

Next, we calculate the Malmquist productivity index along with its components for each state. Instead of presenting the year-wise disaggregated results, we show a summary of the average performance of all states.[4] Recall that if the value of Malmquist index or any of its components is greater than unity, then it denotes improvement in performance between any two adjacent years. Also, it may be necessary to note that these measures capture the performance relative to the best practice one. The performance of TFP in each state is given in Table 3. As it is difficult to summarize the disaggregated results, we include some of their general features. The disaggregated results reveal widespread regional variation in productivity changes. In the sample period of 1993-1994 to 1999-2000, 9 out of 14 states experienced productivity improvement. While during the period of 1993-1994 to 1996-1997, 6 states witnessed growth in TFP, the corresponding number was 7 and 14 during the periods 1997-1998 to 2002-2003 and 2003-2004 to 2004-2005 respectively. During 1993-1994 to 1996-1997, the states experiencing positive growth in TFP were Rajasthan (3%), Kerala (2.3%), Tamil Nadu (1.8%), West Bengal (4.95%), Haryana (0.26%) and Maharashtra (1.15%). This shows that during this period the middle income states experienced higher TFP growth relative to other states. Figure 1 reveals that the variation in TFP has decreased in till 1999-2000, but after that it shows the variation in TFP has increased, though in the period of 2000-2001 to 2004-2005 most of the states witnessed positive TFP growth rates.

The most significant factor behind the improvement in TFP during 1993-1994 to 1996-1997 could be found in improvement in technical efficiency as evident from the positive rates of efficiency change in 12 out of 14 states. Here, it should be noted that during this period, all the states exhibit technical regress, whereas during 2003-2004 to 2004-2005

[4] The disaggregated results for each state and year are available on request.

all the states exhibited technological progress. In the period 1996-1997 to 2002-2003, when the economy witnessed some slowdown in economic growth, the low income states witnessed decline in efficiency change, but the other two categories of states have shown improvement in efficiency, whereas technical progress was of the magnitude of about 1.2% per year among the low income states and it was 1% and 0.7 percent among middle and high income states. Moreover, it is evident that, in the beginning of the liberalization era, it was the improvements in technical efficiency that were contributing towards the growth of TFP, but in the later periods, the growth in TFP is governed by the growth in technical progress. Variation across states in efficiency- and technical change in almost constant up to 1999-2000, but after that it has been increasing (Figure 1).

4.3 Innovative States

It should be noted that the technical progress change index for any particular state between two adjacent years merely depicts the shift in the production frontier for that state. A value of technical change index greater than unity does not necessarily imply that the state under consideration did actually push the frontier outward. Thus in order to determine the states that were shifting the frontier or were 'innovators' (see Färe et al., 1994), the following three conditions are required to be fulfilled for a given state:

(a) $TECH_t^{t+1} > 1$;

(b) $D_o^t\left(\mathbf{x}^{t+1}, \mathbf{y}^{t+1}\right) > 1$;

(c) $D_o^{t+1}\left(\mathbf{x}^{t+1}, \mathbf{y}^{t+1}\right) = 1$.

The condition (a) indicates that the production frontier shifts in case of more outputs for the given level of input. With a given input vector, in period t+1 it is possible to increase output bundle relative to period t. This measures the shift in the relevant portions of the frontier between periods t and t+1 for a state. The condition (b) indicates the production in period t+1 that occurs outside the frontier of period t (i.e., technical change has occurred). It implies that the technology of period t is incapable of producing the output vector of period t+1 with the input vector of period t+1. Hence, the value of output distance function $\left(\mathbf{x}^{t+1},\mathbf{y}^{t+1}\right)$ relative to the reference technology of period t is greater than one. The condition (c) specifies that the state must be on the production frontier in period t+1.

Table 4 shows the states that were innovator. Out of 13 two-year periods, Punjab, which is consistently on the frontier, shifts the frontier only 5 times. Uttar Pradesh (a low income state) shifts the frontier in 1996-1997 over 1995-1996, West Bengal (a middle income state) shifts the frontier 6 times and Gujarat (a high income state) shifts the frontier only in the last two sample years. Note that if a state is technically efficient and is on the production frontier, then it is optimally utilizing its productive potential and there is little to be gained from adopting technology or knowledge from elsewhere. But only the states that were technically efficient were innovative in the sense that they were able to shift the frontier outward in the respective years (Table 4). It implies that although there is a tendency of convergence in productivity growth among Indian states during the liberalization era, only those that are efficient remain innovative also.

4.4 Comparison between the Growth Rates of Malmquist Index and Growth Accounting TFP Measures

To test the robustness of the Malmquist index model specification, we also estimated TFP growth measures for each state using the growth accounting framework. To compute estimates of TFP growth following growth accounting exercise, we require information on the growth rates of inputs and outputs which is explained earlier and is given in Table 1, and on the inputs share of output. Following Bosworth et al. (2007), we assume that the capital share of output is equal to 0.4. The estimates of TFP growth following growth accounting exercise are displayed in Table 5. As with our results for the Malmquist productivity growth, there is high productivity growth per annum over the sample period, however, the correlation coefficient between the two measures of productivity is very high ranging from 0.75 to 0.89 at the interval of different time periods. Given the same set of data for getting the estimates of TFP growth, the question is why the results of two methods differ. First, the two techniques produce comparable results in the absence of technical inefficiency. Second, in the growth accounting exercise using the factor shares of output, the absence of allocation efficiency is assumed. If the factors of production are not paid according to their value of marginal product, the resulting measure of TFP growth will be biased. In calculating the results produced in Table 5, we follow traditional growth accounting framework and no attempt is made to make the estimates direct multilateral comparison. That is, each of the state is compared only to itself in the preceding year, and not to a common benchmark as is used in the calculation of Malmquist index, the national frontier from the data. This may be another reason for diversion in the results.

4.5 Convergence in TFP Growth across States

The convergence hypothesis could be restated in the relationship between productivity and lagged technical inefficiency. This relationship would state those countries that were near the production frontier would see a lower level of productivity growth than those were farther away. Therefore, the negative relationship between productivity level and lagged technical efficiency level would indicate the presence of convergence hypothesis (Lall et al., 2002).

In the present exercise, we find that the states that were closer to the frontier in the efficiency estimation at the beginning of liberalization era are having the higher growth rate in TFP index. The correlation coefficient between the technical efficiency scores in 1993-1994 and the average of Malmquist index over the period 1993-1994 to 1999-2000 or 1993-1994 to 2004-2005 is -0.68 or -0.70, which is statistically significant. Moreover, we find that the states that were farther from the frontier in 1993-1994 have gained not only due to increase in technical efficiency, but also have experienced the higher growth rate of technical progress. This indicates that there is a tendency towards convergence in the productivity growth rates across the states. This finding concurs with Ray (2002) and Kumar (2006) and does not conform to Aghion et al. (2005). Note that these studies were confined to Indian manufacturing only. Aghion et al. (2005) find that the economic reforms help to increase the productivity growth in the states that were closer to the frontier implying increasing divergence in the growth of productivity across states. Note that they use labor productivity rather than TFP to test their hypothesis.

There are major differences across states in the area of economic reforms. The states such as Maharashtra, Tamil Nadu, Gujarat, Karnataka and Andhra Pradesh are more reforms oriented in comparison to Haryana, Kerala, Orissa, Madhya Pradesh, Punjab, Rajasthan and West Bengal. The states such as Bihar and Uttar Pradesh are further slow in implementing economic reforms. Per se, the results shows that the TFP growth is related to the degree to which economic reforms are implemented in a state. But, we find that the TFP growth in higher in the states of West Bengal, Kerala relative to Punjab and Haryana and even relative to Maharashtra and Gujarat who are better in terms of implementing the economic reforms. The explanation can be found in the fact that these states were away from the frontier in the initial years and they had better scope for improving the efficiency and they are endowed with better quality of labor or higher value of human development index. Punjab who is consistently on the frontier and observed negative rate of growth in TFP is required to develop 'appropriate' institutions that encourage competition and innovations in the state. Similar policy prescription is applicable for Haryana.

To examine the relationship between Malmquist productivity adjunct years index and its determinants, we considers variables such as technical efficiency in the previous year, relative per capita state income measured as the ratio of per capita net state domestic product to per capita national net domestic product, physical capital per unit of human capital, value of human development index, and ratio of public to private investment in a state. The source of data on human development index is the Planning Commission (cited from indiastat.com).

If one can establish a positive relationship between (i) relative per capita income and level of productivity and (ii) productivity and capital-labor ratio, the findings go in favor of endogenous growth theories. Higher productivity growth in lower capital-labor ratios states would favor convergence theory because marginal product of capital would be low in high-income states those exhibits a high capital-labor ratio.[5] Human development index can be considered as an indicator for the quality of life in the state. We hypothesize that a state having better quality of life can use resources more productively.

We use fixed effects panel data model to investigate the relationship between TFP level and its determinants. In the regression analysis we use observations for the period 1993-1994 to 1999-2000 only, since beyond this period we obtain capital data through linear interpolation. The regression results are displayed in Table 6. We obtain negative relationship between the lagged technical efficiency and productivity index favoring the convergence hypothesis. The results also show that the sign of capital per efficiency labor unit is negative, again supporting the convergence hypothesis. We find that the sign of the coefficient of relative per capita income is positive. Note that we are testing convergence in TFP growth rather than per capita income so the coefficient should be interpreted as that the states having higher per capita income experience higher growth in TFP. Lastly, we observe that the states having better quality of life are more productive in terms of using the resources efficiently.

5. Conclusions

There has been an extensive progress in the research of economic growth and productivity during the past two decades (e.g., Nghiem and Coelli, 2002; Liao et al., 2007). Previous study focuses on aggregated growth accounting and sector level productivity studies in India. Recently, however, state level capital data becomes available and, therefore, state level empirical analysis becomes possible. The productivity analysis under more flexible assumptions can be made using state level data. Our study

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[5] Here it is important to differentiate between σ - and β - convergences. When the dispersion of income across a group of economies falls over time, there is σ - convergence and the negative partial correlation between growth in income over time and its initial level favors β - convergence. Young et al. (2003) show that β - convergence is necessary for σ - convergence. They show that "σ_t^2 can be rising even if β - convergence is the rule. Intuitively, economies can be β - converging towards one another while, at the same time, random shocks are pushing them apart" (Page 5). The present analysis relates to later category.

contributes to the literature in providing detailed productivity measurement allowing inefficiency in the states and its determinants in India using most updated database.

We find the average level of inefficiency is declining in the liberalization era in India. In the computation of productivity changes, the disaggregated results show widespread regional variation in the changes. Nine states experienced productivity improvement in the period of 1993-94 to 1999-2000.

In the beginning of the liberalization era, improvement in technical efficiency contributes to the growth of TFP. In the later periods, however, the TFP growth is governed by the growth in technical progress. Variation across states in efficiency- and technical change in almost constant up to 1999-2000, but after that it has been increasing.

Though only states that are efficient remain innovators, we find a tendency of convergence in productivity growth among states during the liberalization periods. We also find that the states with better quality of life are more productive in terms of using the resources efficiently. Robust check is provided using the growth accounting framework and the results show high correlation between the two measures though they are different at state level.

References

Acemoglu, Daron, Philippe Aghion, and Fabrizio Zilibotti (2006). "Distance to Frontier, Selection, and Economic Growth." *Journal of the European Economic Association*, 4(1), 37-74.

Aghion, P., S. Redding, R. Burgess and F Zilbotti (2005) 'Entry Liberalization and Inequality in Industrial Performance' *Journal of European Economic Association*, 3(2-3), 291-302.

Ahluwalia, M.S. (2000), "Economic Performance of States in Post Reforms Period", *Economic and Political Weekly,* May 6, pp. 1637-1648.

Arrow K. (1962) The Economic implications of learning by doing. *Review of Economic Studies* 29(3): 155–173.

Barro, Robert (1991), 'Economic Growth in a Cross-Section of Countries', *Quarterly Journal of Economics*, 196(2), 407-443.

Barro, Robert J. and X. Sala-i-Martin (1992), 'Convergence' *Journal of Political Economy*, 100(2), 223-251.

Barro, Robert J., N. J. Mankiw and X. Sala-i-Martin (1995) 'Capital Mobility in Neoclassical Models of Growth, *American Economic Review* 85(1), 103-15.

Baumol W. J. (1986) Productivity growth, convergence and welfare: what the long-run data show. *American Economic Review* 76(5): 1072–1085.

Baumol W.J., Blackman S.A.B., Wolff E.N. (1989) *Productivity and American leadership: the long view*. MIT Press, Cambridge.

Bils, M., Klenow, P., 2000. Does schooling cause growth? *American Economic Review* 90, 1160–1183.

Bosworth, B., Collins, S., Virmani, A., 2007. Sources of growth in the Indian economy. NBER Working Paper W12901.

Breton A. (1996) *Competitive Governments*. Cambridge University Press, Cambridge.

Evans, P. and G. Karras (1996), 'Do Economies converge? Evidence from a Panel of US States' *Review of Economics and Statistics*, 78: 384-388.

Färe R., Grosskopf S., Norris M., Zhang Z. (1994) Productivity growth, technical progress, and efficiency change in industrialized countries. *American Economic Review* 84 (1): 66–83.

Färe, R., Grosskopf S., Lovell C.A.K. (1994) *Production Frontiers*. Cambridge University Press, Cambridge.

Ghosh, B., S. Marjit and C. Neogi (1998), "Economic Growth and Regional Divergence in India, 1960 to 1995", *Economic and Political Weekly,* June 27, 1623-1630.

Goldar, Bishwanath. 2004. "Indian Manufacturing: Productivity Trends in Pre- and Post-Reform Periods," *Economic and Political Weekly* November 20: 5033-42.

Grosskopf S. (1986) The role of the reference technology in measuring productive efficiency. *The Economic Journal* 96: 499–513.

Hall, R.E. and C.I. Jones (1999), "Why do some countries produce so much more output per worker than others?" *Quarterly journal of Economics*, February, pp. 83-116.

Howitt, Peter (2000), 'Endogenous Growth and Cross-Country Income Differences' *American Economic Review*, 90, 829-846.

Klenow, Peter, and Andrés Rodriguez-Clare. 1997. "The Neoclassical Revival in Growth Economics: Has It Gone Too Far?" In *National Bureau of Economic Research*

Macroeconomics Annual 1997, edited by Ben S. Bernanke and Julio Rotemberg. Cambridge, MA: MIT Press. 73-103.

Krishna, K., 2004. Patterns and determinants of economic growth in Indian states. Indian Council for Research on International Economic Relations Working Papers 144.

Kumar, S., 2006. A decomposition of total factor productivity growth: A regional analysis of Indian industrial manufacturing growth. *International Journal of Productivity and Performance Management*, 55(3/4), 311-331

Lakhchaura, P., 2004. Capital formation at state level. Indian Ministry of Statistics and Programme Implementation mimeo.

Lall P., Featherstone A.M., Norman D.W. (2002) Productivity growth in the Western Hemisphere (1978-94): the Caribbean in perspective. *Journal of Productivity Analysis* 17: 213-231.

Liao, H., Holmes, M., Weyman-jones, T. and Llewellyn, D. (2007). Productivity growth of East Asia economies' manufacturing: A decomposition analysis. *Journal of Development Studies,* 43(4), 649-674.

Lucas, R. (1988), 'On the Mechanics of Economic Development' *Journal of Monetary Economics*, 22(1), 3-42.

Mohan R. (2008) Growth record of the Indian economy, 1950-2008: a story of sustained savings and investment. *Economic and Political Weekly*, May 10: 61-71.

Nagaraj, R., A. Varoudakis and M. A. Veganzones (2000), "Long-Run Growth Trends and Convergence Across Indian States", *Journal of International Development,* 12.

Nehru, V., Dhareshwar, A., 1993. A new database on physical capital stock: Sources, methodology, and results. *Rivista de Analisis Economico* 8, 37–59.

Nghiem, HS and Coelli, T (2002) The effect of incentive reforms upon productivity: Evidence from the Vietnamese rice industry. *Journal of Development Studies*, 39 1: 74-93.

Olson M. (1996) Big bills on the side walk: why some nations are rich, and others poor. *Journal of Economic Perspectives* 10(2): 3–34.

Rao, C. H. H. (2008) Growing regional disparities in development in India: post-reform experience and challenges ahead. In Chopra K., Rao C. H. H. (Eds) *Growth, equity, environment and population: economic and sociological perspectives*. Sage Publications, New Delhi, 198-207.

Rao, M. Govinda, R. T. Shand and K. P. Kalirajan (1999), "Convergence of Incomes Across Indian States: A Divergent View", *Economic and Political Weekly,* March 27, 769-778.

Ray S.C. (2002) Did India's economic reforms improve efficiency and productivity? A non-parametric analysis of the initial evidence from manufacturing. *Indian Economic Review* 37: 23-57.

Romer, Paul M. (1990) 'Endogenous Technological Change', *Journal of Political Economy*, 98(5), S71-S102.

Sachs, J., Bajpai, N., Ramiah, A., 2002. Understanding regional economic growth in India. *Asian Economic Papers* 1, 32–62.

Solow, Robert M. (1956) 'A Contribution to the Theory of Economic Growth.' *Quarterly Journal of Economics*, 70, 65–94.

Young A. T., Higgins M. J., Levy D. (2003) Sigma convergence versus beta convergence: evidence from U. S. county-level data. Department of Economics Working Paper, Emory University, Atlanta.

Young, Alwyn (1995) ‘The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience, *Quarterly Journal of Economics*, 110(2), 641-680.

Table 1: Growth Rates of GSDP, Physical Capital and Human Capital across Indian States

State	Gross State Domestic Product (GSDP)				Physical Capital				Human Capital			
	1993-1996	1997-2002	2003-2004	1993-1999	1993-1996	1997-2002	2003-2004	1993-1999	1993-1996	1997-2002	2003-2004	1993-1999
Bihar	3.69	4.28	2.50	4.30	4.15	2.63	2.34	3.44	2.49	2.51	2.52	2.50
Madhya Pradesh	4.45	3.75	9.14	5.24	7.45	4.73	4.25	6.27	4.06	4.16	4.29	4.10
Orissa	1.80	4.98	11.37	4.20	0.03	-1.98	-3.11	-0.88	3.73	3.84	3.97	3.77
Rajasthan	10.19	4.71	11.85	7.89	7.72	5.15	4.86	6.50	4.90	4.99	5.09	4.93
Uttar Pradesh	6.37	2.48	5.08	4.48	10.48	6.91	6.69	8.77	3.91	3.98	4.06	3.94
Andhra Pradesh	5.77	5.53	7.40	5.32	6.45	4.26	4.11	5.38	3.41	3.52	3.66	3.45
Karnataka	6.75	6.93	7.21	7.35	13.02	10.71	10.21	12.19	3.55	3.60	3.66	3.57
Kerala	5.33	4.67	9.32	5.49	3.24	1.82	1.70	2.53	1.87	1.88	1.90	1.88
Tamil Nadu	6.69	4.71	5.93	6.42	5.38	2.82	2.62	4.09	2.27	2.29	2.32	2.28
West Bengal	6.82	6.74	6.83	6.87	1.64	0.04	-0.52	0.88	3.70	3.72	3.73	3.71
Gujarat	11.74	3.24	9.55	7.54	13.40	9.89	9.69	11.86	3.71	3.76	3.81	3.73
Haryana	6.75	5.22	8.18	5.74	9.42	5.83	5.70	7.65	6.52	6.58	6.66	6.54
Maharashtra	6.12	3.77	7.82	6.06	5.46	2.74	2.78	4.04	3.21	3.25	3.30	3.22
Punjab	4.69	3.89	5.68	4.66	7.31	4.08	3.80	5.72	5.32	5.39	5.46	5.35
Low Income States	5.66	3.60	7.05	5.09	7.46	4.71	4.33	6.18	3.83	3.90	3.99	3.86
Middle Income States	6.35	5.75	7.09	6.31	5.89	3.80	3.49	4.91	3.05	3.10	3.15	3.07
High Income States	7.27	3.82	7.95	6.17	7.94	4.88	4.80	6.43	3.96	4.01	4.06	3.98
India	6.41	4.42	7.35	5.85	7.07	4.45	4.19	5.82	3.60	3.66	3.72	3.62

Low income states: Bihar, Orissa, Rajasthan, Madhya Pradesh and Uttar Pradesh.
Middle income states: Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and West Bengal.
High income states: Gujarat, Haryana, Maharashtra and Punjab

Table 2: Level of Technical Efficiency (Unit values)

State	1993-1996	1997-2002	2003-2004	1993-1999
Bihar	1.42	1.21	1.51	1.30
Madhya Pradesh	1.25	1.34	1.59	1.21
Orissa	2.37	2.21	1.85	2.32
Rajasthan	1.22	1.20	1.30	1.16
Uttar Pradesh	1.00	1.18	1.52	1.01
Andhra Pradesh	1.17	1.13	1.21	1.13
Karnataka	1.10	1.20	1.30	1.11
Kerala	1.71	1.44	1.17	1.62
Tamil Nadu	1.60	1.34	1.23	1.51
West Bengal	1.32	1.01	1.00	1.18
Gujarat	1.15	1.12	1.00	1.14
Haryana	1.07	1.08	1.03	1.08
Maharashtra	1.37	1.20	1.07	1.31
Punjab	1.00	1.00	1.00	1.00
Low Income States	1.27	1.31	1.53	1.23
Middle Income States	1.35	1.20	1.18	1.29
High Income States	1.24	1.14	1.04	1.20
India	1.29	1.22	1.25	1.24

Low income states: Bihar, Orissa, Rajasthan, Madhya Pradesh and Uttar Pradesh.
Middle income states: Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and West Bengal.
High income states: Gujarat, Haryana, Maharashtra and Punjab

Table 3: Average Annual Growth Rate of Total Factor Productivity and its Components (Percent)

State	Efficiency Change				Technological Change				Productivity Change			
	1993-1996	1997-2002	2003-2004	1993-1999	1993-1996	1997-2002	2003-2004	1993-1999	1993-1996	1997-2002	2003-2004	1993-1999
Bihar	3.71	0.22	-6.94	3.76	-3.95	2.71	7.63	-2.76	-0.39	2.93	0.16	0.90
Madhya Pradesh	0.14	-4.84	1.31	0.71	-0.63	-1.74	2.39	-0.69	-0.49	-6.50	3.73	0.02
Orissa	-1.28	2.93	7.95	1.13	-0.63	-1.08	1.95	-0.69	-1.91	1.82	10.05	0.43
Rajasthan	5.53	-3.92	4.23	2.77	-2.35	1.66	2.72	-1.03	3.05	-2.33	7.07	1.71
Uttar Pradesh	0.00	-5.97	-3.13	-1.45	-3.20	2.65	3.59	-2.26	-3.20	-3.48	0.35	-3.67
Andhra Pradesh	2.40	-1.28	0.37	1.53	-2.36	2.45	3.30	-1.23	-0.03	1.13	3.69	0.28
Karnataka	-1.65	-2.59	1.79	-1.94	-2.35	0.13	0.64	-1.32	-3.96	-2.46	2.44	-3.23
Kerala	4.76	3.84	6.81	4.16	-2.33	-0.36	0.91	-1.00	2.32	3.47	7.78	3.11
Tamil Nadu	4.19	3.36	2.80	3.85	-2.32	-1.34	0.82	-1.13	1.78	1.98	3.65	2.68
West Bengal	7.48	2.98	0.00	6.76	-2.35	3.27	5.84	-0.90	4.95	6.35	5.84	5.80
Gujarat	2.21	1.58	1.51	0.94	-2.31	-1.81	3.82	-1.60	-0.15	-0.26	5.39	-0.67
Haryana	0.87	0.33	0.64	-0.11	-0.63	-1.74	0.97	-0.69	0.23	-1.42	1.61	-0.80
Maharashtra	3.60	3.02	2.24	3.59	-2.36	2.78	3.62	-1.29	1.15	5.89	5.94	2.25
Punjab	0.00	0.00	0.00	0.00	-1.48	-1.19	0.62	-0.82	-1.48	-1.19	0.62	-0.82
Low Income States	1.36	-3.64	-0.81	0.75	-2.41	1.21	3.75	-1.68	-1.10	-2.48	2.84	-0.94
Middle Income States	3.54	1.16	1.84	2.97	-2.34	1.00	2.54	-1.12	1.12	2.15	4.40	1.82
High Income States	2.49	1.99	1.59	2.10	-2.05	0.71	2.97	-1.23	0.39	2.73	4.62	0.83
India	2.48	-0.20	0.87	1.95	-2.27	0.98	3.08	-1.35	0.14	0.78	3.95	0.58

Low income states: Bihar, Orissa, Rajasthan, Madhya Pradesh and Uttar Pradesh.

Middle income states: Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and West Bengal.

High income states: Gujarat, Haryana, Maharashtra and Punjab

Table 4: Innovative States

Year	States
1994-1995	-
1995-1996	-
1996-1997	Punjab, Uttar Pradesh
1997-1998	-
1998-1999	Punjab
1999-2000	Punjab, West Bengal
2000-2001	West Bengal
2001-2002	West Bengal
2002-2003	West Bengal
2003-2004	Gujarat, Punjab, West Bengal
2004-2005	Gujarat, Punjab, West Bengal

Table 5: Average Annual TFP Growth Rate Based on Growth Accounting Framework

State	1993-1996	1997-2002	2003-2004	1993-1999
Bihar	0.88	3.22	0.25	1.66
Madhya Pradesh	-1.02	-1.84	5.39	0.29
Orissa	-0.36	2.92	10.88	2.47
Rajasthan	4.63	-2.20	8.17	2.61
Uttar Pradesh	-0.19	-2.17	-0.04	-1.45
Andhra Pradesh	1.20	1.56	3.77	1.21
Karnataka	-0.73	0.08	0.98	0.29
Kerala	3.04	3.52	7.94	3.50
Tamil Nadu	3.40	2.05	3.67	3.61
West Bengal	4.14	4.80	5.00	4.49
Gujarat	4.54	-2.39	3.74	0.67
Haryana	-0.95	-1.16	2.04	-1.28
Maharashtra	2.17	1.57	4.99	2.68
Punjab	-1.50	-1.26	0.92	-0.88
low Income State	0.79	-0.01	4.93	1.11
Middle Income State	2.21	2.40	4.27	2.62
High Income State	1.07	-0.81	2.92	0.30
India	1.57	0.58	3.70	1.47

Note: Low income states: Bihar, Orissa, Rajasthan, Madhya Pradesh and Uttar Pradesh.
Middle income states: Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and West Bengal.
High income states: Gujarat, Haryana, Maharashtra and Punjab

Table 6: Determinants of Productivity Change (Fixed-Effects Model)

Variable	Coefficient	*t-statistics*
Technical Efficiency (lagged)	-0.424***	*-4.03*
Relative Per Capita Net State Domestic Product	0.638***	*4.9*
Ln(Physical Capital/Human Capital) (lagged)	-0.162**	*-2.27*
Human Development Index	2.656***	*4.7*
Public Investment/Private Investment	0.005	*-0.49*
Intercept	1.082*	*1.77*
Sigma_u	*0.350*	
Sigma_e	*0.035*	
Rho	*0.990*	
RMSE	*-0.995*	
F (p-value)	*7.67 (0.00)*	
Number of Observations	*84*	

***, **, * mark the level of statistical significance at 1, 5 and 10%, respectively.

Figure 1: Interstate dispersion in technical efficiency, productivity level and its components