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# THE EVOLUTION OF MANUFACTURING EFFICIENCY: EVIDENCE FROM INDIAN STATES

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***Abstract***

*The paper investigates the patterns of variations in Indian industrial performance at both industry and state levels. Applying stochastic frontier analysis to an unbalanced panel of 15 Indian states, 22 industries at the 2-digit level, and an 11-year period spanning 1992-2002; the paper estimates, for each industry group, the relative ranking of states based on their technical efficiency scores, and how these rankings have changed over time. The results represent novel contributions to the growing debate on Indian industrial productivity, albeit from a different perspective. Three primary sets of conclusions arise. First, there is considerable variation across industries in terms of their aggregate efficiency performance. However, overall industrial performance appears to be driven more by input growth, with technical efficiency having a marginal effect at best. Second, results also show considerable regional variation in efficiency patterns, with southern and western states outperforming northern and eastern states in terms of their overall manufacturing efficiencies. Punjab is surprisingly the worst-performing state in the country in terms of this yardstick. Finally, detailed analysis at the state-industry level allows creation of state profiles, which summarise the relative strengths and performances of different industries across those states.*

**JEL codes**: L6, D24, O33

**Keywords**: Manufacturing, technological change, technical efficiency, India

# THE EVOLUTION OF MANUFACTURING EFFICIENCY: EVIDENCE FROM INDIAN STATES

## 1. Introduction

Ever since they were initiated in 1991, the Indian economic reforms have spawned an active debate on just how effective they have been in improving the performance and productivity of Indian industries. Performance, as measured by growth of the industrial sector, indeed appears to have been lacklustre; the average growth of the overall industrial sector between 1997-98 to 2001-02 was only 4.5%, a very marginal improvement over the 4% during the whole of 1970s. Even in decadal terms, average growth during the whole of 1990s was less than 5.9%, compared with an average of 7% during the 1980s. With all the effort that has gone into the reforms process over the last two decades, and the amount of interest this has generated, one is tempted to ask whether it was ‘much ado about nothing’. Furthermore, the federal structure of the Indian constitution – the very foundation of Centre-state relations within the country – clearly demarcates the policies areas falling within the jurisdiction of each. Industrial policies are amongst the few which fall under the purview of both Central and state governments. The most significant implication is that the Central government has little direct control over industrial outcomes across the country. It can devise policies, but the eventual outcomes will depend on how different state governments choose to implement industrial and other policies, including those relating to health and education. Given the heterogeneities in states’ histories, industrial policies, labour relations, and predominant political leanings; considerable variation across states’ industrial performance is not only expected, but inevitable.

It is this variation in inter-state industrial performance that is investigated here. This paper addresses the growing debate on industrial productivity in India, albeit from a different angle. Rather than seeking to provide explanations for productivity performance, this paper calculates, for each industry group, the relative ranking of states’ performances based on their efficiency scores, and how these rankings/scores have changed over time. This is done using stochastic frontier analysis, which is based on the premise that even though all producer aim to optimise, not all are successful in doing so. A secondary goal of the paper is to calculate technical progress of broad industries categories, and compare its impact (relative to that of technical efficiency) on industrial performance. The analysis is undertaken at three different levels of aggregation, commensurate with the goals of the research. Consequently, the results are presented at the industry (aggregated across states), state (collective performance across industries), and industry-state levels. A strategy such as this has not been attempted till now.

The results are quite illuminating and informative. Industries predictably enough show great variation in terms of their efficiency and technical progress. However, there does not appear to be any consistent correlation between technical efficiency, factor intensities, and overall performance. Capital- and labour-intensive industries have increased and decreased their capital intensities, respectively, but on the whole have improved performance, as measured by their gross value added/capital (GVA/capital). This indicates that industries have responded well to the new post-reforms environment, irrespective of their efficiency rankings. A possible explanation for this anomalous result is that industrial performance (at least in the decade immediately following reforms) is driven more by inputs growth, with efficiency having a marginal effect at best. The results regarding overall efficiency performance of states are also quite interesting and validate common perceptions about states. In general, western and southern states far outperform the northern and southern states in efficiency of their manufacturing sectors. Moreover, the better performing states are also typically those reputed to have more pro-business environments and investment climates, while those with relatively poor efficiency are those known for relatively poor education and health standards, and a poor law and order record. The most surprising result is that of Punjab, which, contrary to all expectations, is the worst performing state in the country in terms of manufacturing efficiency. Its position worsens even further as the post-reform decade progresses.

The paper is structured as follows: Section 2 summarises the key relevant literature and inherent gaps; Section 3 discusses literature gaps and research goals; Section 4 describes the methodology and data used; Section 5 details the results; and Section 6 concludes.

## 2. Literature Review[1]

The concept of Stochastic Frontier Analysis (SFA)[2,3] originated in 1977 with the nearly simultaneous papers by Meeusen and van den Broeck (1977) and Aigner, Lovell, and Schmidt (1977). Since this time, empirical applications of the SFA have spawned a large body of literature, with the technique being applied for different types of frontiers (production, cost, or revenue), and using data for a wide range of industries and countries.

While SFA is quite similar to ordinary least squares (OLS) in terms of its econometric underpinnings, they both differ in some key respects. Unlike OLS, which treats all cross-sectional units as operating at full technical efficiency (with output variations attributed solely to statistical noise), SFA allows for differences in performance due to deterministic, firm-specific characteristics. In doing so, SFA introduces a level of realism in the analysis that is missing in standard OLS methods. A second important difference is that OLS measures performance relative to the average producer, while SFA does so relative to a frontier, representing full efficiency of performance. The underlying, defining assumption in SFA therefore is that that while all cross-sectional units seek to operate at full efficiency, not all are equally successful in doing so. To paraphrase Kumbhakar and Lovell (2003), not all producers are equally adept at *getting the best bang for the buck*. The more efficient a producer is, the closer it will be to the efficiency frontier (i.e. maximum attainable efficiency), and the less efficient it is, the further away it will be.

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1 This literature review briefly summarises only the key and relevant strands. A more detailed literature review is available from the author upon request. This applies more to the growth accounting literature, which has been extensively applied to many countries and industries over varying timeframes. However, only a few India-specific applications are reviewed here.

2 The origins of efficiency literature itself predates SFA by about 26 years, to the works of Koopmans (1951), Debreu (1951), and Shephard (1953). While Koopmans first postulated and defined the concept of technical efficiency, the latter two introduced distance functions as a way of modelling multi-output technology. These distance functions differed only in their orientation, with Debreu's model explaining efficiency in terms of output expansion possible with a given vector of inputs, while Shephard doing so in terms of the minimum inputs required for producing a given vector of outputs. Farrell (1957) was the first to empirically measure productive efficiency, by first defining and measuring costs efficiency of U.S. agriculture, and then decomposing this into its technical and allocative components (Kumbhakar and Lovell (KL), 2003).

3 Empirical studies using firm-level data usually involve frontier-based productivity analysis techniques that can further be classified into econometric, parametric techniques such as Stochastic Frontier Analysis (for one output), Distance Functions (the multi-output counterpart of SFA), Corrected or Modified OLS; or into mathematical, non-parametric linear programming technique of Data Envelopment Analysis. The primary goals in these studies are the comparison of productivity scores across firms, and the explanation of these scores using exogenous variables. These strands collectively represent a very large body of literature. Since this paper is based on SFA, these other strands of literature are not reviewed here. However, the section on methodology will present a brief comparative discussion of these techniques, and outline why these techniques are not deemed appropriate for the present analysis.

The empirical applications have tracked the theoretical evolution of SFA from cross-sectional to panel data models, and from explaining the determinants of efficiency variations within a two-stage framework to a single-stage one, wherein determinants of production/cost and technical efficiency are estimated simultaneously. The reader is referred to Kumbhakar and Lovell (2003) for a comprehensive survey of papers illustrating this evolution. Lovell (1995) also provides a brief yet pertinent survey of the diverse frontier-based applications, ranging from agricultural efficiency and measurement of standard of living, to analysis of product & service quality. Other applications of firm-level SFA cover efficiency of healthcare delivery in USA (Rosko and Mutter, 2007) and educational outcomes in Portugal (Pereira and Moreira, 2007), benchmarking of cost structures of electricity distribution networks in Switzerland (Filippini et al, 2001), and productivity growth of the services sector in Singapore (Mahadevan, 2002). Yet other disparate examples of technical efficiency estimation relate to Australian dairy farms (Kompas and Nhu Che, 2004), rice production in Vietnam (Kompas, 2004), and offshore oil and gas drilling in the Gulf of Mexico (Managi et al, 2006). Two oft-cited applications in the Indian context are that of Battese and Coelli (1992), who measure technical efficiency of paddy farmers, and Kumbhakar and Sarkar (2005), who look at the effects of deregulation and ownership on the changing efficiency patterns of Indian banks.

All the above examples relating to stochastic frontier analysis illustrate the broad applicability of the technique, but have three important features in common First, SFA is limited to firms to firms within specific industries. To the best of my knowledge, *there are no applications of SFA which compare the performance of firms across industries*. Second, *the stochastic frontier approach is applied, without exception, to cases where there is only one well-defined output, or where multiple outputs can be aggregated into a single aggregate measure or output index*. This is directly due to the theoretical underpinnings of the SFA framework, which is based on comparisons of individual firms' production functions relative to some optimal industry (technology) frontier. Inter-industry comparisons would be meaningless (for example, comparing the performance of a textile-producing firm with that of a machinery-producing firm), since the basket of goods produced across industries reflect different embodied technologies, and therefore, different production frontiers. **Being the over-riding theoretical prerequisite, this comparability of production functions** is most readily achieved when using highly disaggregated firm-level data, so as to ensure that outputs, inputs, and firm characteristics are as homogeneous as possible. On the other end of the spectrum, comparability can also be achieved by resorting to highly aggregate data, such as comparisons across countries (or states within countries) rather than across firms. This clear dichotomy (in level of aggregation) is the third feature of the literature. Suffice to say that empirical applications of SFA in the latter case are far rarer.

Pires and Garcia (2004) is one of the few studies to apply the SFA to aggregate data. They construct a sample of 75 countries spanning a 30-year period from 1970-2000, and analyse the relative efficiency of countries in terms of their GDP and aggregate inputs. For a smaller sub-sample of 36 countries, they apply the methods of Bauer (1990) and Kumbhakar et al (2000) to decompose TFP estimates into allocative and technical efficiency, scale effects, and technical change. Greene (2003) analyses health outcomes (efficiency of healthcare delivery) in a production function framework for a panel of 140 countries, using a large dataset of the World Health Organisation (WHO).

An important application of SFA to state-level data in the Indian context is that of Jha et al (1999), which measures tax efficiency of major Indian states for the period of 1980-81 to 1992-93. The authors also address the important policy issue of moral hazard, wherein greater access to central government grant are found to have a detrimental effect on the efficiency with which states collect their own taxes. Chakarabarti and Rao (2007) uses SFA to evaluate the efficiency of healthcare provision across India using a panel of 14 Indian states for the period 1986-95, with (in)efficiency itself being determined by a variety of socio-economic factors. She creates an index of efficiency for states and finds wide regional disparities in the efficiency of health provision. These works by Jha et al. and Chakrabarti and Rao provide good precedents for applying SFA techniques to aggregate state-level data.

## 3. Literature Gaps and Research Questions

As the literature survey in the preceding section indicates, the paucity of state-level technical efficiency analysis in general,[4] and the particular absence of any such analysis in the Indian industrial context represent a clear gap in the literature. There is no systematic investigation *whatsoever* of how the efficiency performance of Indian states, *across broad industrial groups*, fares relative to that of each other; and how this performance has evolved over time. As such, an effort to investigate the patterns of and variations in industrial efficiency across states and industries addresses the identified gap, and represents an important and timely contribution to the literature.

[4] As mentioned earlier, the only two papers applying frontier techniques to aggregate Indian state-level data do so in context of tax collection and the provision of health services.

The proposed contribution is important for four reasons. First, this could be a referendum on how well various state governments have seized the opportunities presented by reforms to improve their overall industrial performances. For example, improved ranking across several industries by a particular state could be taken as evidence of a sound industrial environment in that state. Conversely, consistently reduced rankings in any state could reflect a failure to seize the initiative. Second, it could contribute to a better understanding of which industries do well in which states, and the reasons for these differences. The comparative advantage of states, not only in terms of industries, but also generally (whether a state is better oriented for industrial activities, or for agriculture or services industries) will depend on natural resource endowments, geographical and historical factors, as well as deliberate government policies. Policies themselves are not just those which affect industrial directly (industrial/financial/trade), but also social policies relating to health, education, and law & order, etc. Third, evaluating this information in conjunction with other information will help determine whether technical efficiency is actually an important factor in industrial outcomes, or whether this debate is something of a 'storm in a teacup'. Finally, rather than imposing *a priori* hypotheses to explain industrial performance, this strategy lets the data do the talking. Analysing results by state, industry, and state-industry categories will yield insights that otherwise would be lost or not investigated at all.

### *Research Questions*

The previous section established the importance of investigating the patterns of and changes in efficiency rankings of states across different industrial groups over time. A satisfactory analysis of this requires answering three sets of specific questions:

1. What are the efficiency scores (and associated rankings) of Indian states' industrial performance, across individual industry groups? Can this performance pattern be explained in terms of states' comparative advantages and/or resource endowments?

2. What is the overall performance of individual states across all industry groups combined? Which are the most and least industrially efficient states in the country; and which are the regions most or least conducive to industrial activity?

3. How has overall industrial performance responded to changes in economic environment? Specifically, how have the capital intensity, technical efficiency, and technical progress of industries evolved in the post-reforms decade, and what is the relative importance of these for industrial performance?

# 4. Empirical Framework and Data

## *Empirical Framework*

The empirical analysis in this paper is based on stochastic frontier analysis,[5] which measures the performance of individual cross-sectional units relative to some efficient frontier. As mentioned earlier, techniques for frontier-based efficiency analyses can be broadly classified into parametric techniques based on econometric estimation, and non-parametric techniques based on linear programming. The most common technique in the former category is that of SFA, while in the latter, it is that of data envelopment analysis (DEA). Consequently, the primary difference between the two relates to the *a priori* requirement for specification of the underlying production technology. Absence of the need for *a priori* specification is a major advantage of DEA, since it is helps uncover structural relationships that would otherwise remain hidden with other methodologies. Moreover, unlike SFA, DEA is capable of handling multiple outputs (along with multiple inputs). Unlike SFA, however, DEA attributes all cross-sectional variation to deterministic factors only, i.e. 'all deviations from the frontier are assumed to be the result of technical efficiency' (Coelli et al, 2005, pp. 242). This failure of DEA to account for measurement errors and other sources of statistical noise is its primary shortcoming, and makes it unsuitable for the present analyses.

The specific estimation framework used in this paper employs a standard translog production function, which, being of a flexible form, provides a good second order approximation to an underlying arbitrary production function. The overall time period used for this study, i.e. 1992-2002, is divided into two equal time sub-groups, 1992-97 and 1998-2002, and estimation is done for both of these. Moreover, time-invariant efficiencies are assumed for the respective time sub-groups. The primary output is a detailed state-industry matrix of technical efficiency scores for each of the two time periods, which can then be summarised by industry or state, or evaluated as it is to get detailed evolution patterns for technical efficiency over time.

[5] For a more detailed exposition on alternative techniques for efficiency analysis and their relative merits, interested readers are referred to Kumbhakar and Lovell (2003) and Coelli et al (2005).

The empirical analysis in this paper is based on a standard stochastic production frontier[6] framework (see Coelli et al, 2005), with the specific estimation equation given by:

(1) $$\ln y_{st} = \beta_0 + \theta_1 t + \theta_2 t^2 + \sum_{n=1}^{4} \beta_n \ln X_{n,st} + \sum_{n=1}^{4}\sum_{m=1}^{4} \ln X_{n,st} \ln X_{m,st} + v_{st} + u_{st}$$

where $y_{st}$ is the log of real output and $x_{st}$ be the vector of inputs; state is indexed by s ϵ [1,S], and time by *t*. Regressions are industry-specific, i.e. they are done separately for each industry, over the two different time periods. The time variable is included in the main production function in quadratic form to account for exogenous technical change and macroeconomic shocks that affect all industries equally. As discussed earlier, the consolidated error term is split into a random component ($v$) and a deterministic component ($u$). To ensure that the frontier envelopes all firms from above, a non-negativity constraint is imposed on non-random component, such that $u_{st} \geq 0$. The production function and the technical inefficiency component are both estimated in the same stage.

The primary research goal of this paper is only to obtain the efficiency scores, rather than test hypothesis about the *causes* of differences in these scores. To this end, estimation equation 1 is based only on a standard production function that gives the relationship between output and inputs, instead of having any state-level policy variables.

The output from frontier analysis is a vector of 'scores', with each element of this vector corresponding to a particular cross-sectional unit (producer). These scores show how far a particular producer is from full efficiency, and consequently, how the performance of each producer fares relative to that of all others. A hypothetical example best illustrates this: suppose that there are three producers only (X, Y, & Z), and the associated TE scores for each are, respectively, 0.95, 0.80, and 0.60. This means that producer X is the most efficient of the three, achieving, as it does, 95% of maximum attainable efficiency. By contrast, producer Z is the least efficient, with only 60% of maximum attainable efficiency, while producer Y is somewhere in between the two.

[6] The production function is the *dual* of the cost function, i.e. one is effectively the inverse of the other. While production functions are concerned with output maximisation (maximising the output for a given set of inputs), cost functions are concerned with cost minimisation (minimising the cost of producing a given level of output). While both are equally valid, the choice of the specific function form depends on the research goals. Given the goal, in the present research context, of analysing production (not cost) efficiency, the production function is the more appropriate choice.

Appendix 3 summarises the standard consistency and symmetry restrictions that were imposed and/or tested for completeness. The empirical estimation in this paper required over 44 regressions,[7] and presenting the diagnostics for all of these would not be feasible in this thesis. Moreover, as they are not relevant for the purposes of the research goals, these are not presented here, but are nevertheless available from the author on request.

## *Data*

The primary data source for this paper is the Annual Survey of Industries (ASI), which is published by the Central Statistical Office (CSO)[8] of India. This covers the registered manufacturing sector, accounting for about 58-67% of total manufacturing (Unel, 2003). Specifically, production data for 22 industries at the 2-digit level (of the National Industrial Classification, NIC), across 15 states is used for this paper. These 15 states collectively account for about 95% of the Indian population. Where larger states underwent a division to create two states, the information for the latter were aggregated to get to the original state, so as to make the later observations comparable to earlier ones. Econometric estimation is based on an 11-year period (spanning the years 1992-93 till 2002-03), which is divided into two comparable sub-groups of 1992-97 and 1998-2002.[9] The choice of years for the sub-groups is motivated more by convenience rather than anything else.

The inputs used are capital, labour, materials, and fuels. Except for labour, all other variables were in nominal values, which were then deflated using appropriate deflators. The *Wholesale Price Index* (WPI) and *Price Index for Fuels* are both available from the Handbook of Industrial Policy and Statistics (HIPS). The series for gross capital stock is created using the Perpetual Inventory Method (PIM). This method takes into account overall productive life of capital and retirement patterns, in addition to new investments (Coelli et al, 2005). The specific formulation used for creating the capital series is taken from Goldar (2004), and is described in Appendix 2. The measure for labour includes both skilled and unskilled

[7] Separate regressions for each of the 22 industry groups, repeated for the two time sub-groups. Moreover, comparisons of state efficiency scores (for each individual industry group) over the two time periods required same functional form in *both* time periods, i.e. either translog or Cobb-Douglas. Therefore, if for any industry, if production function in either period was found to be Cobb-Douglas, then the other was also re-estimated using a Cobb-Douglas production function, and *then* the efficiency results for both periods compared.

[8] The Central Statistical Office, a part of the Ministry of Statistics and Programme Implementation (MOSPI), is tasked with classifying industries according to their primary economic activities, in accordance with the principles and procedures laid out in the United Nations International Standard Industrial Classification (ISIC) framework. The NIC is accordingly prepared and revised from time to time, to suit both current and evolving Indian conditions. Finally, information collected from individual firms in the Annual Survey of industries is aggregated according to the NIC.

[9] As of writing this paper, the latest available aggregate data from ASI is only up till 2003-04.

components, while materials include all intermediate inputs sourced from other industries for use in the production process. Fuels cover all types of fuels (kerosene, diesel, petroleum, coal, etc) used in production. The (real) value of labour, and the nominal values for materials and fuels are as reported in the official ASI statistics.

The deflator for capital is the implicit price deflator, which is derived from real and nominal values for Gross Fixed Capital Formation (GFCF) (both are available from the website of the Reserve Bank of India). The deflator for material inputs in each industry group, based on the basic guideline provided by the US Department of Labour,[10] was created as the weighted average of price indices of products used as inputs in that industry. The weights are calculated using the 1993-94 Input-Output Table for India, which is available from the CSO website. Detailed price indices for individual components are available from the website of the *Office of the Economic Advisor (OEA).*

## 5. Results and Discussion

This section details and discusses the results of the empirical analysis. These results, as indicated above, are organised into three broad sections, and presented for industries (aggregated across states), states (collective performance across industries), and individual industry-state combinations.

### *Overall Performance by Industries*

The first set of results relate to overall industrial performance, and aims at a comprehensive understanding of relative industrial performance. The first graph gives the average technical efficiency scores for the different industries (aggregated across individual states), for the three time periods: 1992-1997, 1998-2002, and the consolidated period 1992-2002. The legend table in Appendix 1 lists out industry codes and corresponding industry name at 2-digit level of the NIC Classification. For four of the industries (Textiles, Machinery & Equipment, TV and Communications Equipment, and Other Transport Machinery), results are not available for one of the time subgroups.[11] The consolidated time period result is therefore useful for some context and comparison. The noticeable result is that average efficiency has fallen or remained approximately same in 10 of the industries considered

[10] See http://www.bls.gov/lpc/iprmfp00.pdf

[11] The results could not be obtained because Stata was showing the production function to not be concave.

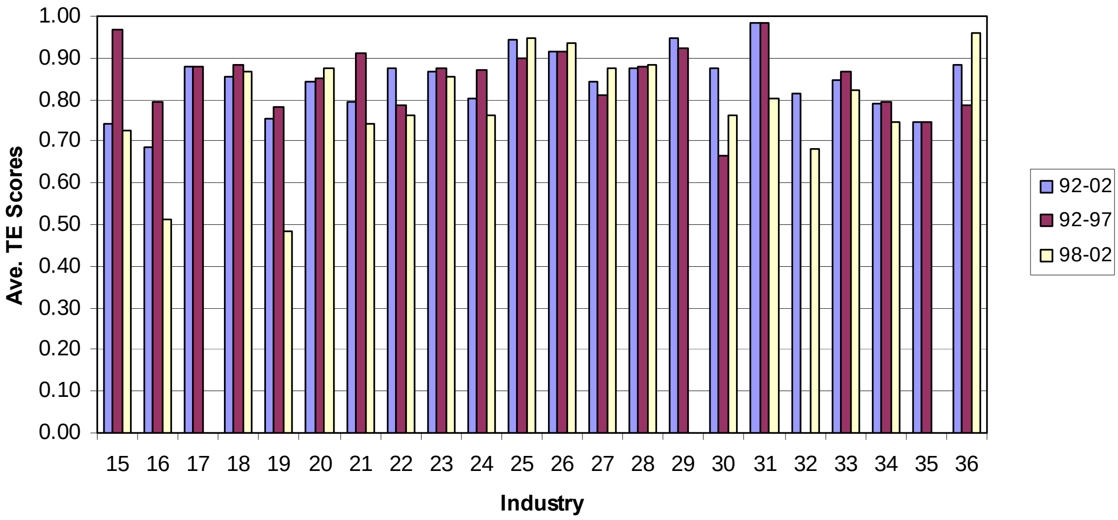
(which is just over half), but the magnitudes of the falls vary significantly. In another 8 industries the average efficiency has risen, while the remaining four do not have comparable results. In the last case, however, comparisons can be made with the overall aggregate and results inferred (*the relative score patterns for the three time periods are quite obvious and consistent across the industries*). In the case of Textiles and Other Transport Equipment industries, the 92-97 average efficiency is almost exactly the same as that for the consolidated 92-02 time period, which lends itself to the conclusion that the average efficiency for 98-02 would also be comparable to the other two, if not lower. As an additional check, it can be considered that in the Motor Vehicles and Trailers industry, the overall and 92-97 efficiencies are almost same, but the efficiency for 98-02 is actually lower. For Machinery & Equipments industry, the average efficiency for 92-97 is lower than that for the overall time period, while in the case of Radio, TV and Communications Equipment industry, the efficiency for 98-02 is well below the efficiency for the overall period. From these, it can be reasonable inferred that for Machinery and Equipments, average efficiency increased between 92-97 and 98-02; while that for Communications Equipment, it fell between the time sub-groups. The overall result therefore stands thus: *for 13 out of 22 industries (almost 60%), the average efficiency remained the same or actually declined between the two time periods, while it increased for 9 industries (40%)*. Assuming that one of the key implicit goals of the reforms period was to increase productivity of industries, the failure of realising this goal in nearly 2/3$^{rd}$ of the industries considered does not appear to be a very encouraging result.

It is at this point that caution must be exercised against premature judgements about the effectiveness of reforms, given that many of the reform initiatives have been industry-specific, and even more importantly, took into account each industry’s unique characteristics and historical evolution. For example, parts of textiles, chemical products, and furniture industries were and are reserved for the small scale industries sector, where political considerations prevented or at least slowed down the removal of products from the small scale reservations.

The most obvious limiting factor in this analysis is that it is based on 2-digit industries only. Each industry comprises a very wide range of products, spanning different technologies and regulatory environments. In fact, it is the rule rather than the exception that various reforms (including liberalisation and tariff reductions) have been applied to at least the 3-digit industry level, if not 4- or 5-digit levels. Therefore, simply using 2-digit industries aggregates away many of these important and relevant details.

Nevertheless, some important inter-industry comparisons are still possible. For example, it seems reasonable to divide the 22 industries in this study into light and heavy industries, based on capital-labour ratios with half representing relatively 'light', labour intensive industries, while the remaining representing heavy, more capital-intensive industries. This seems reasonable precisely because the aggregated categories hide away so much heterogeneity. For example, a capital-intensive industry like chemicals also includes activities like production of soaps etc, which are to a large extent labour intensive and confined to the small scale sector.

**Fig. 1: Average TE Scores by Major Industry Group**




Typically, industry-specific reforms first implemented in 1991 can broadly be classified into three categories: first, the drastic reduction of import and tariff duties to bring them in line with those prevailing internationally (these were primarily relevant for capital and raw materials imports); secondly, removal of scale restrictions and associated red tape; and finally, automatic approval of foreign direct investment. The overall performance of any industry will depend, though not exclusively, on the relative magnitudes and speeds of each of these. Furthermore, evaluations with respect to efficiency and technical progress changes must be made within a wider industrial context, which also encapsulates overall industrial growth rates and further categorisations of respective industries.

Tables 1 and 2 illustrate this well. Table 1 summarises, by 2-digit industry, categorisation[12] (heavy/light), percent changes in capital-labour ratios, technical progress in each industry, and changes in average TE scores (this is just an alternative representation of the information given in Figure 1). The last four columns are associated with industrial growth rates. Table 2 is further based on Table 1, and gives the capital-labour ratios for the total time period (on which the industry categorisation is based) and the two time sub-groups; and also gives the percentage change in these between the two time periods.[13] It shows that between 1992-97 and 1998-2002, only 7 industries experienced an increase in their capital labour ratios, and of these the top 6 were Heavy (capital-intensive) industries. Thus, 6 Heavy industries became even more capital intensive, some substantially more so. Only one industry hitherto classified as Light (labour intensive) became more capital intensive. The biggest gainers have been the Transportation and Furniture industries, while the Coke and Refined Petroleum industry had by far the highest capital-labour ratio in all three time-periods.

All these results seem reasonable based on anecdotal observations. For example, one would expect capital intensity in the motor vehicle industry to increase, given the proliferation of foreign car manufacturers since the advent of reforms; the capital-intensive nature of the coke and refined petroleum industries is already well-acknowledged. Conversely, the remaining 15 industries, regardless of category, saw their K/L ratios actually fall, meaning that these industries became more labour intensive. Given that the large across-the-board tariff cuts (documented elsewhere) were purportedly to promote capital imports and adoption of state-of-the-art technology, this part of the result is surprising and somewhat counter-intuitive, and can be taken as evidence of the lacklustre results of tariff cuts.

Capital-Labour ratios, while being an important indicator of industrial activities, nevertheless do not lend themselves to judgements about industries' performances themselves. For example, we cannot justifiably conclude that a reduction in an industry's K/L ratio is tantamount to worsening performance.

[12] This was based on capital-labour ratios which were derived from the ASI data. K/L ratios for each industry were averaged across the 11 years, and sorted in descending order. The average of the 11th and 12th ranked industry was taken as the median, and all industries greater or less than the median were taken as Heavy or Light, respectively.

[13] It seems strange to take the percentage change of a ratio, but this is important for making meaningful comparisons. For example an absolute change of 1.2 in the ratio signifies different things when ratio goes from 1 to 2.2 and from 10 to 11.2.

**Table 1: Industrial Performance Summary (by H/L category)**

| Industry | Heavy/ Light* | K/L Ratio Δ | Mean TP Δ** | Mean TE Δ | Industrial Growth Rates | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | 92-07 | 98-02 | % Δ | 92-02 |
| **15** | *Light* | -18.6% | -6.3% | -21.2% | 7.4% | 5.7% | *-1.7%* | 6.6% |
| **16** | *Light* | -36.9% | 83.5% | -29.7% | 4.8% | 4.9% | *0.2%* | 4.8% |
| **17** | *Light* | -18.3% | | | 8.7% | -1.2% | *-9.9%* | 4.2% |
| **18** | *Light* | -59.0% | -97.9% | 22.1% | 14.7% | 5.5% | *-9.2%* | 10.5% |
| **19** | *Light* | -3.5% | -148.4% | -28.9% | 7.1% | 1.1% | *-6.1%* | 4.4% |
| **20** | *Light* | -51.0% | -53.2% | 2.7% | 6.0% | 8.1% | *2.2%* | 6.9% |
| **22** | *Light* | 25.6% | -38.6% | 1.6% | 8.2% | 4.0% | *-4.2%* | 6.3% |
| **25** | *Light* | -29.1% | 50.2% | 5.1% | 10.8% | 3.4% | *-7.4%* | 7.4% |
| **28** | *Light* | -5.9% | 59.7% | 0.1% | 9.4% | 0.6% | *-8.7%* | 5.4% |
| **29** | *Light* | -18.0% | | | 6.5% | 2.1% | *-4.5%* | 4.5% |
| **33** | *Light* | -40.5% | -217.4% | -4.3% | 9.0% | 8.6% | *-0.4%* | 8.8% |
| **21** | Heavy | -3.9% | -35.2% | -18.8% | 5.0% | 7.3% | *2.2%* | 6.1% |
| **23** | Heavy | 46.3% | -7.3% | -2.1% | 11.1% | 23.1% | *12.0%* | 16.6% |
| **24** | Heavy | -19.8% | 11.9% | -10.9% | 11.5% | 2.1% | *-9.4%* | 7.3% |
| **26** | Heavy | -37.1% | -0.8% | 1.9% | 4.9% | 3.4% | *-1.5%* | 4.2% |
| **27** | Heavy | -15.2% | 2.5% | 6.5% | 9.6% | 1.8% | *-7.8%* | 6.1% |
| **30** | Heavy | -21.1% | 170.3% | -28.9% | 13.4% | 3.8% | *-9.7%* | 9.0% |
| **31** | Heavy | 103.1% | 34.2% | -18.2% | 7.7% | 0.8% | *-6.9%* | 4.6% |
| **32** | Heavy | 38.2% | | | 13.4% | 8.5% | *-4.9%* | 11.1% |
| **34** | Heavy | 120.6% | 5.1% | -4.8% | 16.8% | 8.8% | *-8.0%* | 13.1% |
| **35** | Heavy | 373.1% | | | 7.3% | 5.4% | *-2.0%* | 6.4% |
| **36** | Heavy | 162.8% | 32.6% | 22.4% | 24.7% | 17.7% | *-7.0%* | 21.5% |

*Source: Author's own computations, based on technical efficiency scores obtained from empirical analysis.*

** Heavy/Light classification was based on the K/L ratio. These were arranged in descending order, and the industries with K/L ratios greater than the median were deemed Heavy industries, and the remaining, Light.*

*** Technical progress is the measure of shift in the production frontier over time. For each industry, the coefficients of regressions from the two time periods, when combined with the actual input values for the 1992-97 period, yielded the respected fitted values. These were labelled y* and y**, respectively, and the logarithmic difference between the two values taken as a measure of technical progress. Mean TE and TP are the simple averages of TE and TP, respectively, over all the states. For a more detailed exposition, see Kalirajan and Shand (1997).*

It may be the case that prior to reforms, an industry employed an inefficiently large amount of capital, which was shed subsequently in order to drive efficiency improvements. Table 3 summarises the growth rates of industries (this is repeated from Table 1) along with changes in capital-labour ratios and in gross value added (GVA) as a proportion of capital stock. This information is sorted by changes in GVA/Capital (changes in GVA is often taken as a good indicator of economic performance, reflecting an industry's ability to earn profits).

### Table 2: % Change in K/L ratios (in descending order)

| Industry | Category | *Capital-Labour Ratios* 1992-02 | 1992-97 | 1998-02 | % Δ in K/L Ratio |
|---|---|---|---|---|---|
| **35** | Heavy | 6.6 | 2.4 | 11.5 | 373.1% |
| **36** | Heavy | 6.8 | 3.9 | 10.2 | 162.8% |
| **34** | Heavy | 12.7 | 8.3 | 18.2 | 120.6% |
| **31** | Heavy | 5.9 | 4.0 | 8.2 | 103.1% |
| **23** | Heavy | 38.3 | 31.4 | 46.0 | 46.3% |
| **32** | Heavy | 5.6 | 4.8 | 6.6 | 38.2% |
| **22** | *Light* | 2.4 | 2.2 | 2.7 | 25.6% |
| **19** | *Light* | 3.0 | 3.0 | 2.9 | -3.5% |
| **21** | Heavy | 5.6 | 5.7 | 5.5 | -3.9% |
| **28** | *Light* | 1.3 | 1.3 | 1.2 | -5.9% |
| **27** | Heavy | 7.5 | 8.1 | 6.9 | -15.2% |
| **29** | *Light* | 2.9 | 3.2 | 2.6 | -18.0% |
| **17** | *Light* | 2.6 | 2.9 | 2.4 | -18.3% |
| **15** | *Light* | 1.3 | 1.4 | 1.1 | -18.6% |
| **24** | Heavy | 5.5 | 6.0 | 4.8 | -19.8% |
| **30** | Heavy | 5.0 | 5.5 | 4.4 | -21.1% |
| **25** | *Light* | 3.1 | 3.5 | 2.5 | -29.1% |
| **16** | *Light* | 2.2 | 2.7 | 1.7 | -36.9% |
| **26** | Heavy | 3.3 | 4.0 | 2.5 | -37.1% |
| **33** | *Light* | 2.8 | 3.4 | 2.0 | -40.5% |
| **20** | *Light* | 1.2 | 1.5 | 0.7 | -51.0% |
| **18** | *Light* | 1.8 | 2.4 | 1.0 | -59.0% |

Table 3 shows the absence of any consistent pattern between changes in K/L ratios, GVA as a proportion of capital, and average growth rates. Even though Heavy industries have become more capital intensive and Light industries have become more labour intensive, and average growth rates have fallen, we see that most industries have improved their GVA/capital ratios. This is a highly significant result, implying that even though industries may be shedding excess capital, they are making better use of whatever capital they are left with. It could also mean that excess obsolete capital is being replaced with less but latest-technology capital, which is allowing the industries to become more lean and competitive.

Of the 22 industries in the study, only 7 industries had reductions in GVA/capital, with one of these being a very marginal 1.4% reduction. The magnitude of the reduction in Rubber and Plastics industry, on the other hand, (536%) is noteworthy. Another noteworthy observation is that the Coke and Refined Petroleum industry, while recording the largest increase in average growth rate, also experienced the second-largest *reduction* in GVA as a proportion of capital. Whether this is a genuine anomaly or a result of measurement error is not known, but certainly warrants further investigation. A possible explanation could be that the industry as a whole undertook massive capital investments in the decade following the reforms, which triggered the growth, but the full benefits of those investments did not fully start showing up in terms of value added in the period of the study. Even so, one would expect the GVA to *grow* by a smaller rate, not contract, and that too by such an extent.

**Table 3: Changes in Gross Value Added / Capital, by Industry**

| Industry | Category | % Δ in K/L Ratio | Category | % Δ in GVA/Cap | Industrial Growth Rates | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | 92-07 | 98-02 | Change | 92-02 |
| **33** | *Light* | -40.5% | High GVA | 761.5% | 9.0% | 8.6% | *-0.4%* | 8.8% |
| **32** | Heavy | 38.2% | High GVA | 672.8% | 13.4% | 8.5% | *-4.9%* | 11.1% |
| **18** | *Light* | -59.0% | High GVA | 626.6% | 14.7% | 5.5% | *-9.2%* | 10.5% |
| **36** | Heavy | 162.8% | High GVA | 476.1% | 24.7% | 17.7% | *-7.0%* | 21.5% |
| **27** | Heavy | -15.2% | *Low GVA* | 225.8% | 9.6% | 1.8% | *-7.8%* | 6.1% |
| **15** | *Light* | -18.6% | High GVA | 131.9% | 7.4% | 5.7% | *-1.7%* | 6.6% |
| **24** | Heavy | -19.8% | High GVA | 114.8% | 11.5% | 2.1% | *-9.4%* | 7.3% |
| **29** | *Light* | -18.0% | High GVA | 75.8% | 6.5% | 2.1% | *-4.5%* | 4.5% |
| **26** | Heavy | -37.1% | *Low GVA* | 70.3% | 4.9% | 3.4% | *-1.5%* | 4.2% |
| **19** | *Light* | -3.5% | *Low GVA* | 44.3% | 7.1% | 1.1% | *-6.1%* | 4.4% |
| **28** | *Light* | -5.9% | High GVA | 42.0% | 9.4% | 0.6% | *-8.7%* | 5.4% |
| **16** | *Light* | -36.9% | High GVA | 32.0% | 4.8% | 4.9% | *0.2%* | 4.8% |
| **17** | *Light* | -18.3% | *Low GVA* | 18.5% | 8.7% | -1.2% | *-9.9%* | 4.2% |
| **21** | Heavy | -3.9% | *Low GVA* | 7.5% | 5.0% | 7.3% | *2.2%* | 6.1% |
| **35** | Heavy | 373.1% | *Low GVA* | 6.1% | 7.3% | 5.4% | *-2.0%* | 6.4% |
| **20** | *Light* | -51.0% | High GVA | -1.4% | 6.0% | 8.1% | *2.2%* | 6.9% |
| **34** | Heavy | 120.6% | High GVA | -84.3% | 16.8% | 8.8% | *-8.0%* | 13.1% |
| **30** | Heavy | -21.1% | *Low GVA* | -93.3% | 13.4% | 3.8% | *-9.7%* | 9.0% |
| **31** | Heavy | 103.1% | *Low GVA* | -111.9% | 7.7% | 0.8% | *-6.9%* | 4.6% |
| **22** | *Light* | 25.6% | *Low GVA* | -117.4% | 8.2% | 4.0% | *-4.2%* | 6.3% |
| **23** | Heavy | 46.3% | *Low GVA* | -138.8% | 11.1% | 23.1% | *12.0%* | 16.6% |
| **25** | *Light* | -29.1% | *Low GVA* | -534.9% | 10.8% | 3.4% | *-7.4%* | 7.4% |

Increases in the GVA/capital for the remaining 15 industries range from 761% to 6%, with some of the largest increases being for industries that shed capital. The logical overall conclusion here appears to be that most industries have managed to respond in a favourable way to economic conditions and incentives, thereby shedding or acquiring capital, as required, in order to improve their overall performance (as given by the GVA).

These industries have been able to use their remaining capital in an efficient way to increase their GVA. However, it is interesting to note that almost all industries, regardless of capital intensity or GVA changes, have reduced average growth rates.

With regards to the industrial growth rates, the first noteworthy thing is the general decline in growth rates *across* industries, regardless of category; in most cases, the average growth rates in the 1992-97 time period is higher than that in the 1998-02 time period. Only three industries experienced increased average growth, with two of these being fairly marginal (2.2% each). *The tobacco industry had increased average growth of a paltry 0.2%*. Of these three, the Coke, Refined Petroleum Products, and Nuclear Fuel industry experienced double digit average growth of 12% p.a.

This pattern of reduced growth has been used to further support an argument against the effectiveness of industrial reforms. However, it must be said that the 1992-97 period was bound to see faster growth due to the low base, since industrial restrictions at the outset of reforms meant that industries were producing at inefficient levels to begin with. This growth was bound to slow down with time, since it difficult, if not impossible to maintain such high growth levels over extended periods. What stands out, however, is an apparent disconnect between TP/efficiency and industrial growth. In fact, there appears to be no definable pattern between the two.

With regards to relative magnitudes of technical efficiency and technical progress, we see that technical progress has been far more volatile than is the case with efficiency. There are only 3 industries, i.e. Food Products, Non-Metallic Mineral Products, and Basic Metals, where the magnitude of the technical progress was less than efficiency change. There also does not appear to be any consistent pattern between the direction of change for the two. For example, for Rubber and Plastic Products, average technical progress and efficiency growth is 50% and 5%, respectively; in case of Wearing Apparel, technical progress fell by almost 98% while efficiency increased 22%; and finally, for Office and Computing Machinery industry, technical progress improved by a substantial 170% but efficiency fell 29%. In each of these 3 cases, average growth rates fell, with the Wearing Apparel and Office Machinery industries each falling by over 9% and Rubber/Plastics industry growth falling by over 7%.

### *Performance of Industries in terms of Technical Efficiency and Progress*

Further insights can be gained from a comparison of industry category with technical progress and efficiency results. For the Light industries, not only does the K/L ratio fall for all but one industry, there is also a general pattern of reduction in technical progress – except for 3 industries i.e. tobacco, Rubber/Plastics and Fabricated Metal Products, all other industries have experienced reduced technical progress. In terms of technical efficiency in Light industries, only the Wearing Apparel and Fur industry had a substantive technical efficiency improvement of 22%. In all other cases, either TE fell substantially, or any improvements were relatively marginal.

For Heavy industries, the results are more mixed. Not only did 6 of the 11 industries increase their K/L ratios, but *the magnitudes of these increases were far greater than the magnitude of reductions in the remaining 5; the smallest percentage increase was 38.2% for Radio, TV, and Communications Equipment industry, while the largest reduction was 37.1% for Other Non-Metallic Mineral Products*. Additionally, for three of the Heavy industries in which K/L ratios declines, the technical progress actually increased, with Office and Computing Machinery industry registering the largest growth in technical progress at 170%. In absence of other information, a probable explanation seems to be that these industries have retired a lot of old capital and replaced it with new better technologies, but the former effect still outweighs the latter. However, this only remains a conjecture. There does not appear to be any consistent pattern in the technical efficiency performance of heavy industries.

Average technical efficiency changes across light and heavy industries are almost identical (-5.8% and -5.9%, respectively). There is an obvious disconnect between TP and efficiency change on one hand and average industrial growth on the other. This illustrates what appears to be the relative unimportance of technical factors in industrial growth, and could be taken as evidence that industrial growth in India is more dependent on inputs rather than on efficiency. It may be that in future, the role of efficiency takes on greater relative importance, but in the present analysis, we can say that just acquiring newer or latest technology would by itself not be sufficient to achieve or sustain higher industrial growth.

To summarise this section, we can say that on the whole, heavy, capital-intensive industries have become even more capital-intensive and have successfully implemented more and better technologies. The light, more labour-intensive industries, on the other hand, have become more labour-intensive. But the change in capital intensity of industries by itself does not allow us to make judgements about the relative performance of industries, or about their ability to respond to changing economic conditions. However, given that most industries have improved their average GVA/capital over time shows that industries have responded well over time, shedding or acquiring capital as necessary, while improving their returns from the remaining capital.

### *Overall Performance by States – Summaries based on TE scores*

This section includes a summary of overall state rankings, based on technical efficiency scores. For each industry, states were ranked according to their technical efficiency scores. The table 4 summarises those rankings in the following way: The first and last columns (rank=1 and rank=15) summarises the number of times a particular state is ranked the best or worst across all industry groups. For example, there are 4 industries in which Karnataka is ranked as the top performing state in 1992-97, while there are 5 industries in which Punjab is ranked the worst-performing state in the same time period. However, the obvious problem is that these extreme ranking would be sensitive to choice of years and to data measurement errors. Therefore, to account for these, the columns 2 and 3 summarise, respectively, the number of time a particular state is ranked in the top three and the bottom 4. Taking Andhra Pradesh as an illustrative example, Table 4 shows that there are 4 industry groups in which the state is ranked amongst the top three, while there are 2 industry groups in which it is ranked amongst the four worst performing states. Such classification is based on the assumption that ranking may vary by one or two due to errors, etc, but by considering the top 3 or bottom 4 would take care of these fluctuations. Finally, Tables 4 and 5 summarise the overall state rankings for the two time subgroups 1992-97 and 1998-02, with Table 5 being organised in exactly the same way as is Table 4. Collectively, the two tables show how each state's relative position has changed over time. Considering the example of Karnataka, we see that it was ranked top in 4 industries in both time periods, and in the top three in 7 and 6 industries, respectively. Similarly, the number of industries in which it is ranked worst and in the bottom 4 changed from 2 and 5 to 0 and 2, respectively. Collectively, these results indicate that not only has Karnataka maintained its overall good industrial performance, but has also managed to pare down its bad performance, thereby casting the overall state performance in a positive light.

While the above conclusion is reasonable, an obvious additional caveat needs to be emphasised. While the number of industries in which it is ranked first has remained constant at 4, the actual industries themselves are not the same. Alternatively, it is not the same 4 industries in which it has achieved the top ranking. The same caveat needs to be applied for all other columns, for each state. To reiterate, tables 4 and 5 only summarise overall state performance, without going into performances at specific industry levels. A second and very important caveat that needs emphasis relates to the fact that the relative state rankings are based on TE scores. In several cases these scores vary by very small margins, but nevertheless affect rankings. More specifically, even very small variations in scores can lead to rankings being changed between the two time subgroups, even though these score variations could be due to minor variations in data. Therefore, one must maintain a certain amount of scepticism when looking at ranking near each other (for example, ranks of 1 and 2, etc).

**Table 4: Overall State Rankings in 1992-97**

| | Rank=1 | Top 3 | Bottom 4 | Rank=15 |
|---|---|---|---|---|
| Andhra Pradesh | 1 | 0 | 0 | 0 |
| Assam | 1 | 0 | 0 | 0 |
| Bihar | 2 | 0 | 0 | 4 |
| Gujarat | 1 | 0 | 0 | 2 |
| Haryana | 0 | 0 | 0 | 0 |
| Karnataka | 4 | 0 | 0 | 2 |
| Kerala | 4 | 0 | 0 | 0 |
| Madhya Pradesh | 0 | 0 | 0 | 1 |
| Maharashtra | 2 | 0 | 0 | 2 |
| Orissa | 2 | 0 | 0 | 2 |
| Punjab | 0 | 0 | 0 | 5 |
| Rajasthan | 2 | 0 | 0 | 1 |
| Tamil Nadu | 0 | 0 | 0 | 1 |
| Uttar Pradesh | 0 | 0 | 0 | 0 |
| West Bengal | 2 | 0 | 0 | 1 |

Several interesting results can be gleaned from these two tables. Overall, in 1992-97, Kerala is the best performing state in efficiency terms, top rank in 4 industries and top three ranks in 10. There is only one industry in which it is ranked in the bottom 4. Karnataka is the second-best performing state.

**Table 5: Overall State Rankings in 1998-2002**

| | Rank=1 | Top 3 | Bottom 4 | Rank=15 |
|---|---|---|---|---|
| Andhra Pradesh | 0 | 0 | 0 | 3 |
| Assam | 2 | 0 | 0 | 1 |
| Bihar | 1 | 0 | 0 | 2 |
| Gujarat | 2 | 0 | 0 | 0 |
| Haryana | 0 | 0 | 0 | 1 |
| Karnataka | 4 | 0 | 0 | 0 |
| Kerala | 1 | 0 | 0 | 0 |
| Madhya Pradesh | 1 | 0 | 0 | 0 |
| Maharashtra | 4 | 0 | 0 | 0 |
| Orissa | 0 | 0 | 0 | 0 |
| Punjab | 0 | 0 | 0 | 7 |
| Rajasthan | 2 | 0 | 0 | 2 |
| Tamil Nadu | 1 | 0 | 0 | 1 |
| Uttar Pradesh | 0 | 0 | 0 | 0 |
| West Bengal | 1 | 0 | 0 | 2 |

Thus southern states are the top performers in the period immediately after reforms. Punjab and Bihar are the worst performing states, with Punjab ranking overall lowest, with worst performance in 5 industries and bottom 4 performance in 12 out of 22 industries! While one would expect Bihar to be a poor performer, given its record; the performance of Punjab comes as a surprise, given its reputation as a dynamic, prosperous state.

The relatively poor performance of Gujarat, and the overall relative comparability of efficiency performances of Maharashtra, Orissa, and Rajasthan are the other notable surprises. One would expect Gujarat to be doing far better that it is, and Maharashtra would do significantly better than the other two. The other states with relatively poor performances are Madhya Pradesh, Uttar Pradesh, and West Bengal. Bihar, with its poor law & order situation and overall unfavourable business climate; and West Bengal, with its history of Marxist governments, would be expected to fare poorly. But in that vein, even Kerala would be expected to be a poor performer. One can only infer that the superior performance in Kerala is due to its record as having the highest literacy rates and health outcomes in the country; by itself, these would show the importance of health and education in affecting better industrial outcomes.

For the period 1998-2002, several expectations come to pass. For example, in this time period, Punjab and Bihar continue to be the worst performing states. Bihar has the worst educational and social record in the country, and its continued poor performance is to be expected.

Nevertheless, it is the best performer in the Basic Metals industry, and this could be explained by the fact that two of the country's largest and best-performing industrial groups (Tatas and Birlas) have significant related presence in Bihar (the Tata group has actually established an entire city in Bihar). The continued poor performance of Punjab can only be explained by the fact that it is predominantly an agricultural state with a particular lack of focus on the manufacturing sector efficiency. Maharashtra expectedly is now the best performing state (it is tied with Karnataka – the second-best performing state – in terms of best performances, but is a poor performer in fewer industries). Assam has also made large overall gains. Kerala has gone from being the best performer in 1992-97 to making the maximum losses in 1998-02; this would possibly explain that while educational and health are important contributors to industrial performance, by themselves they are not enough.

State governments also need to foster a conducive business environment and productive industrial policies to achieve better results. Andhra Pradesh also made large losses in overall position, and this pattern can be possibly be explained by the fact that growth in this state is more driven by the services and BPO sector, at the expense of the manufacturing sector efficiency.

It is strongly emphasised that all these explanations, while highly probable based on anecdotal and popular belief, need to be further tested empirically. Nevertheless, they validate one of the key goals of this paper, i.e. of identifying areas for further meaningful research.

A brief observation on the regional groupings is also in order here. The western states of Gujarat and Maharashtra have been the biggest gainers, while Rajasthan (another western state) has also made good gains. The eastern state of Bihar is the second-most worst performing state, while West Bengal too is a relative poor performer. However, Assam has made impressive productivity gains. The southern states of Andhra Pradesh and Kerala have made considerable losses too, while Karnataka has maintained its overall good performance. Tamil Nadu's relative position remains intermediate. In terms of the northern region, Punjab is the worst performing state, while Uttar Pradesh too ranks amongst states with the worst efficiency performance. Haryana's performance has been mixed, with it moving from an overall intermediate position towards the extremes, coming amongst the top and worst performing states rank in more industries. Madhya Pradesh, the only central state, also made significant overall improvements, mostly moving from the bottom towards intermediate performance in several industries. Therefore, it is a reasonable assessment that western states are the most efficient in the country, while the eastern and northern states are the least efficient. Madhya Pradesh and parts of south India are also reasonably efficient. These assessments validate many commonly accepted anecdotal beliefs about the efficiency of states, and can be explained largely in terms of the political leanings of the main parties (Communist parties in Kerala and West Bengal), law & order situations (Bihar and Uttar Pradesh), and comparative advantage (Punjab).

### *Detailed analysis: State-Specific Results*

The final part of the results relates to cross-state technical efficiency scores estimated *for each industry group* separately for both 1992-97 and 1998-02. The efficiency scores obtained from each set of regressions allows the ranking of states' efficiency for each industry group, in both time periods. Comparing the rankings across the two time subgroups shows how these have changed for industry-state combinations, and allows a detailed set of inferences to be drawn. A detailed, consolidated state-industry matrix shows the ranking results. To correctly interpret the results, consider the first cell (Andhra Pradesh in industry 15, i.e. Food and Beverages) as an illustration: in 1992-97, Andhra Pradesh was the second-most efficient state in producing food and beverage products, but in 1998-02, it had lost 4 places to become the sixth-most efficient state. The fist cell thus shows the deteriorated efficiency performance of AP only in the Food and Beverages Industry. Conversely, West Bengal was the most efficient state for this industry in 1992-97, but had lost 13 places by 1998-02 to become and second-most *inefficient* state in the same industry, which represents a far worse deterioration than that suffered by Andhra Pradesh.

Therefore, reading down the columns (by industry), we can tell which states are performing well or poorly in each industry; or reading along the rows, we can start deciphering the strengths of each state in terms of which industries they are good or bad in. This section aims to provide only brief snapshots of results for each *state*, and seeks to provide only cursory explanations in a few cases where these would be generally well-accepted.[14] The reason for this is that the consolidated table 6 is a very comprehensive summary of results, and communicating those results meaningfully is a substantial task in itself. It is hoped that this insights and pattern gleaned from this study will be used as basis for more specific and targeted analysis subsequently. Explanations of observed patterns should also be a part of these later exercises.

**Andhra Pradesh**: Most significant gains have been in the Motor Vehicles industry (34) and Office and Computing Machinery (30), both of which are heavy industries. AP has gained 13 positions to reach top rank in the former and 6 positions to reach second rank in the latter. It has also gained 6 positions each in the light industries of Tobacco (16) and Wearing Apparel (18), but in these the progress has been from fairly low positions to intermediate ones. In all other industries, there is a general declining pattern, which is consistent with the observation that on the whole, the state has fared poorly in efficiency terms.

[14] A similar exercise if possible for industries as well, i.e. reading down the columns will show, for each industry, which states have high/low efficiency and how these have changed over time. Interested readings can easily use the table to conduct such analysis.

**Assam:**[15] Largest gains in efficiency ranking have been in the Chemicals and Related Products industry, where it gained 10 positions to reach second rank. In addition to the result above, it has also progressed well enough to enter into the top 3 ranks in four of the industries: Paper/Paper Products (21), Chemicals and Products (24), Other Non-Metallic Mineral Products (26), and Electrical Machinery and Apparatus (31). What is noteworthy is that all 5 industries listed above are classified as heavy industries; this pattern of performance certainly merits closer attention and investigation. In the labour-intensive Food Products and Beverages industry, Assam actually lost 4 positions to reach $15^{th}$ rank, which is the lowest rank. This is highly surprising, since Assam is one of the main tea producing regions in the country. Given the size of Assam's tea industry and the importance of tea in Indian households, it is expected that Assam should, at the very least, be a good performer in production of tea, and this should be reflected in the rankings. Its good performance in the Paper industry is expected, given the large presence of the paper industry in Assam traditionally.

**Bihar**: Bihar has maintained its first and third ranks, respectively, in the heavy industries of Basic Metals and Motor Vehicles, Trailers & Semi Trailers. It also gained 9 ranks each in two other heavy industries – Paper and Paper Products, and Electrical Machinery and Apparatus. In terms of light industries, it lost 8 positions in the tobacco industry but gained 11 positions in the Fabricated Metal Products industry, which is quite closely related to basic metals industry. In all other industries, rankings either remain constant or any movements are very marginal. Bihar therefore appears to have a relative strength in heavy industries, its poor law and order record notwithstanding. A possible reason could be that Bihar is one of the largest coal producing states in the country, which in turn is a very important input for electricity generation in general (which is critical for heavy industries), and for the metals industry in particular (since coal is also needed for metal extraction, in addition to electricity generation). Being close to one of its most important inputs would therefore be good for the efficiency of heavy industries.

[15] Assam is the smallest state in India in terms of relative share of manufacturing output. There appears to be some anomalies in the industrial data of the Annual Survey of Industries, since based on this data and the subsequent analysis, Assam is found to have very high efficiency levels in Motors Vehicles and Trailers, and Wood Product Industries, respectively, when in fact official documents reveal that there is no presence of these industries in this state. A possible explanation could be that some related industries have been classified into these groups, and production shown as efficient, when in fact there is little or no production happening. Due to these factors, the anomaly is mentioned here for the sake of completeness of results, but no further discussion is made of these industries, even though estimated results indicate otherwise.

**Gujarat**: Of the 18 industries for which we have results, there were only 6 industries in which Gujarat lost rankings. Furthermore, in four of these six industries, Gujarat lost only 2 positions each, representing marginal losses at worst. In all other industries, the state either gained rankings, or maintained them. This pattern is consistent with the earlier observation about Gujarat being one of the biggest gainers in overall efficiency rankings between 1992-97 and 1998-02. These results also validate Gujarat's reputation as one of the most business friendly states in the country.

**Haryana**: The state has intermediate efficiency rankings in most of the industries. However, there have been a few notable improvements. For example, the state gained 9 positions in the Coke and Refined Petroleum Products industry to reach 2$^{nd}$ rank, and also gained 6 positions to reach 2$^{nd}$ rank in the Printing and Publishing industry. These gains are matched by large losses in other industries. There does not appear to be any consistent pattern of performance across industry category.

**Karnataka**: The largest loss of ranks that Karnataka had were in the Leather and Coke & Refined Petroleum products industries, where it lost 8 and 7 positions, respectively. This is more than offset by the large gains it has made in several other industries: in the two light industries of Wood Products and Rubber/Plastics Products, it gained 11 and 13 positions to reach 2$^{nd}$ and 1$^{st}$ rank, respectively. It also gained 14 positions to go from 15$^{th}$ rank to 1$^{st}$ rank in the manufacturing of Electrical Machinery and Apparatus. Most other changes are marginal, with the overall results being consistent with Karnataka's growing reputation as a regional manufacturing powerhouse, regardless of capital-intensity of industry.

**Kerala**: Kerala lost ranking positions in 12 out of 18 industries. While the magnitudes of reductions vary, the overall results are consistent with the earlier observation that Kerela has lost overall competitiveness across industries. An interesting observation is that of the 6 industries in which Kerala improved its rankings, 5 are labour-intensive industries. By itself, this seems reasonable, and indicates the relative strength of Kerala as an industrial destination. Another notable result relates to the magnitude of the loss of ranking in the Rubber and Plastics Products industry, where it lost 8 positions. This is surprising precisely due to the fact that Rubber is one of the traditional industries in Kerala, with anecdotal evidence suggesting that a non-trivial part of the population is directly involved in the wider rubber industry (including the agricultural side).

**Madhya Pradesh**: MP has improved its rankings in 9 industries, but in most cases, it has moved from very low ranks to intermediate ranks, which shows an overall pattern of improvement. However, the greatest magnitudes of improvements have been in light industries. It actually gained 13 ranks to attain top position in the Food Products and Beverages industry, while in four other light industries, it gained between 5 and 6 ranks. There is only one relatively capital-intensive industry, i.e. Furniture, where the state had a comparable performance in ranking improvements (by 5 positions). But even here, it could be argued that small scale restrictions apply to significant chunks of the industry, so the performance of Furniture industry is more in line with performance of the light industries. *Again, as in other cases, these results show something about the evolving areas of industrial strength for the state.*

**Maharashtra**: This is the state with the greatest overall improvement in competitiveness, as measured by ranking improvements across industries (from Tables 4 and 5). Rankings improved in 11 out of 18 industries, with the maximum being in Food Products and Beverages (increase of 13 ranks, from 15$^{th}$ to 2$^{nd}$ position) and in Paper and Paper Products (increase of 12 rank, from 15$^{th}$ to 3$^{rd}$). Other large improvements were in Coke and Refined Petroleum Products, and Other Non-Metallic Mineral Products (an improvement of 9 and 7 ranks, respectively, to attain the top position in both industries). Except for Food Products and Beverages, all other three industries are capital-intensive. On the downside, the state lost 9 ranks in the labour-intensive Leather industry to move from 1$^{st}$ to 10$^{th}$ position. It also moved up one notch to attain top position in the Publishing and Recorded Media industry, which is again not unexpected, given that India's largest film industry is based in the state. Therefore, not only has the state experienced the maximum improvement in its overall position, but has experienced extreme changes in the efficiency performances in some industries. On the whole, there appears to be a shift towards heavy industries, which could be explained by the state's known propensity towards pro-business policies.

**Orissa**: Except for a few exceptions, the magnitude of rank changes across industries are relatively moderate. The most notable change is in the Rubber and Plastics Products industry, where the state lost 8 ranks (from 1$^{st}$ to 9$^{th}$ position). This is exactly like in the case of Kerala, and significant because Rubber is an important industry in both states. It also lost 7 ranks each in the other light industries of Tobacco and Wearing Apparel. In terms of heavy industries, it gained 5 and 6 ranks, respectively, in Motor Vehicles and Furniture industries, but in both cases it has moved from the very bottom towards intermediate positions. In all other heavy industries, rank changes are very marginal. Thus most of the movement in the state has been in light industries, but the largest movements have been in the downwards direction. This does not augur well for a state that considers light industries as its forte.

**Punjab**: Punjab lost rankings in 10 industries, but even more significantly, in most cases these represented moves from intermediate to low positions. The Electrical Machinery and Apparatus industry registered the greatest drop of 13, corresponding to a move from 2$^{nd}$ to 15$^{th}$ position. In 3 of the remaining 8 industries, the state's rankings were unchanged – in Publishing & Reproduction of Recorded Media, and Rubber/Plastics Products, Punjab remained at the 15$^{th}$ rank, while in Medical Instruments it remained at 13$^{th}$ rank. All these 3 industries are classified as labour intensive. The only industry with any significant positive movement is the Furniture industry, where the state gained 9 ranks to move from 9$^{th}$ to 3$^{rd}$ position. In the remaining 3 industries where the state gained, it improved it rank by 3 positions each; of these 4 industries where rank improved, 3 are capital-intensive and only one is labour-intensive. Therefore there appears to be a significant deterioration in the overall condition of light, labour-intensive industries in the state.

**Rajasthan**: The state maintained its top position in Chemicals and Products, and gained 3 positions to attain top position in Fabricated Metal Products. Moreover, it attained or maintained its good position in 4 other industries. On the downside, the state lost 10 ranks to move from 2$^{nd}$ to 12$^{th}$ position in the Motor Vehicles and Trailers industry, and lost 7 ranks each in 3 other industries. In terms of factor intensities, Rajasthan had greater fluctuations (in either direction) in capital-intensive industries, while fluctuations in labour-intensive industries have been far more moderate. Overall, there does not appear to be any pattern of improvement/decline across industry categories.

**Tamil Nadu**: The overall efficiency performance of the state has been relatively static, with most changes in rankings best characterised as moderate. The few exceptions are in Chemicals and Products, where the state gained 10 ranks to attain 3$^{rd}$ position, and Motor Vehicles and Trailers, where it lost 9 ranks to reach 13$^{th}$ position. It also gained 7 ranks to attain 8$^{th}$ position in Wood and Wood Products industry which, unlike the previous two, is a labour-intensive industry. As with Rajasthan, there does not appear to be any consistent pattern favouring either capital- or labour-intensive industries.

**Uttar Pradesh**: In 3 of the 8 capital-intensive industries, the state's efficiency ranking was unchanged, while it increased marginally in only one case. In the remaining 4 industries the rankings fell, with the largest being in Motor Vehicles and Trailers, where the state lost 8 ranks to reach 14th position. This is a significant change, given that Maruti, the country's largest car manufacturer, has a significant manufacturing presence there. Therefore, depending on how one interprets the static rankings in the 3 industries, the overall pattern in capital-intensive industries has been moderately to highly negative. The pattern in light industries is more mixed, with some ranking improving in some industries and deteriorating in others. The greatest gains have been in the Tobacco; and Printing, Publishing and Reproduction of Recorded Media industries, while the greatest decline has been in the Leather industry. For context, the undivided state of Uttar Pradesh (prior to its break up into two states) was the most populated in India.

**West Bengal**: The efficiency performance of West Bengal is a bit hard to interpret without reference to its political history. This state, along with Kerala, are the only 2 states in India with a long history of communist rule, aptly reflected in the pro-worker orientation of the industrial policies. Both the industrial environment and performance are known to have deteriorated sharply over the last few decades. In this context, it seems reasonable that in 6 of the 8 labour intensive industries, WB has improved its rankings, though in most cases the movements are getting the state to intermediate positions at best. In Food Products and Beverages, the state lost 13 ranks to go from 1st to 14th position. It bolstered its position in the Fabricated Metals industry. Among the heavy industries, it maintained its top position in the Furniture industry, and gained 7 ranks to attain 7th position in the Chemicals and Products industry. Efficiency changes in other heavy industries have not yielded encouraging results, with most movements in either direction keeping the state at fairly low ranks. As stated elsewhere, the Furniture industry, even though classified as capital-intensive, has large parts of it restricted to the small scale sector. Therefore, WB appears to have a clear tilt towards light, labour-intensive industries.

## Table 6: Disaggregated Efficiency Rankings (1992-97, 1998-02, and changes in these)

| State | 15 | 16 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|
| Andhra Pradesh | 2 , 6 , -4 | 11 , 5 , 6 | 12 , 6 , 6 | 13 , 14 , -1 | 8 , 12 , -4 | 3 , 6 , -3 | 9 , 9 , 0 | 2 , 11 , -9 | 4 , 6 , -2 |
| Assam | 11 , 15 , -4 | , 3 , -3 | | | 2 , 1 , 1 | 4 , 1 , 3 | 1 , 10 , -9 | 7 , 4 , 3 | 12 , 2 , 10 |
| Bihar | 8 , 7 , 1 | 1 , 9 , -8 | 14 , , 14 | 11 , 13 , -2 | 12 , 15 , -3 | 13 , 4 , 9 | 13 , 13 , 0 | 15 , 14 , 1 | 6 , 8 , -2 |
| Gujarat | 3 , 5 , -2 | 14 , 13 , 1 | 11 , 7 , 4 | 14 , 8 , 6 | 9 , 3 , 6 | 12 , 10 , 2 | 7 , 11 , -4 | 1 , 7 , -6 | 8 , 10 , -2 |
| Haryana | 6 , 8 , -2 | 10 , 10 , 0 | 2 , 8 , -6 | 3 , 3 , 0 | 4 , 11 , -7 | 7 , 14 , -7 | 8 , 2 , 6 | 11 , 2 , 9 | 9 , 15 , -6 |
| Karnataka | 13 , 11 , 2 | 5 , 1 , 4 | 3 , 9 , -6 | 4 , 12 , -8 | 13 , 2 , 11 | 5 , 5 , 0 | 3 , 5 , -2 | 6 , 13 , -7 | 2 , 5 , -3 |
| Kerala | 9 , 3 , 6 | 3 , 4 , -1 | 8 , 3 , 5 | 2 , 1 , 1 | 10 , 7 , 3 | 1 , 7 , -6 | 4 , 3 , 1 | 3 , 6 , -3 | 5 , 12 , -7 |
| Madhya Pradesh | 14 , 1 , 13 | 2 , 7 , -5 | 9 , 4 , 5 | 7 , 2 , 5 | 5 , 9 , -4 | 11 , 12 , -1 | 11 , 14 , -3 | 13 , 9 , 4 | 10 , 9 , 1 |
| Maharashtra | 15 , 2 , 13 | 13 , 8 , 5 | 5 , 1 , 4 | 1 , 10 , -9 | 1 , 4 , -3 | 15 , 3 , 12 | 2 , 1 , 1 | 10 , 1 , 9 | 3 , 4 , -1 |
| Orissa | 4 , 4 , 0 | 7 , 14 , -7 | 4 , 11 , -7 | 10 , 5 , 5 | 3 , 5 , -2 | 10 , 8 , 2 | 12 , 6 , 6 | 9 , 10 , -1 | 15 , 14 , 1 |
| Punjab | 12 , 13 , -1 | 4 , 12 , -8 | 7 , 13 , -6 | 12 , 9 , 3 | 7 , 14 , -7 | 14 , 11 , 3 | 15 , 15 , 0 | 14 , 15 , -1 | 11 , 13 , -2 |
| Rajasthan | 7 , 10 , -3 | 12 , 15 , -3 | 1 , 2 , -1 | 5 , 7 , -2 | 6 , 13 , -7 | 6 , 13 , -7 | 10 , 12 , -2 | 4 , 3 , 1 | 1 , 1 , 0 |
| Tamil Nadu | 10 , 12 , -2 | 6 , 11 , -5 | 6 , 10 , -4 | 9 , 4 , 5 | 15 , 8 , 7 | 2 , 2 , 0 | 6 , 7 , -1 | 12 , 12 , 0 | 13 , 3 , 10 |
| Uttar Pradesh | 5 , 9 , -4 | 8 , 2 , 6 | 10 , 5 , 5 | 6 , 11 , -5 | 14 , 10 , 4 | 9 , 9 , 0 | 14 , 8 , 6 | 5 , 5 , 0 | 7 , 11 , -4 |
| West Bengal | 1 , 14 , -13 | 9 , 6 , 3 | 13 , 12 , 1 | 8 , 6 , 2 | 11 , 6 , 5 | 8 , 15 , -7 | 5 , 4 , 1 | 8 , 8 , 0 | 14 , 7 , 7 |

| State | 25 | 26 | 27 | 28 | 30 | 31 | 33 | 34 | 36 |
|---|---|---|---|---|---|---|---|---|---|
| Andhra Pradesh | 11 , 13 , -2 | 2 , 10 , -8 | 4 , 7 , -3 | 8 , 11 , -3 | 8 , 2 , 6 | 1 , 6 , -5 | 10 , 12 , -2 | 14 , 1 , 13 | 6 , 15 , -9 |
| Assam | 7 , 5 , 2 | 6 , 2 , 4 | 6 , 6 , 0 | 6 , 9 , -3 | | 10 , 3 , 7 | | 11 , 2 , 9 | 3 , 6 , -3 |
| Bihar | 12 , 12 , 0 | 14 , 15 , -1 | 1 , 1 , 0 | 15 , 4 , 11 | , 4 , -4 | 11 , 2 , 9 | 3 , 5 , -2 | 3 , 3 , 0 | 11 , 11 , 0 |
| Gujarat | 5 , 2 , 3 | 4 , 4 , 0 | 8 , 8 , 0 | 13 , 8 , 5 | 7 , 1 , 6 | 8 , 10 , -2 | 7 , 9 , -2 | 12 , 4 , 8 | 8 , 7 , 1 |
| Haryana | 8 , 6 , 2 | 9 , 13 , -4 | 5 , 2 , 3 | 10 , 7 , 3 | 5 , 7 , -2 | 14 , 7 , 7 | 9 , 4 , 5 | 9 , 5 , 4 | 4 , 5 , -1 |
| Karnataka | 14 , 1 , 13 | 5 , 5 , 0 | 12 , 4 , 8 | 1 , 3 , -2 | 1 , 3 , -2 | 15 , 1 , 14 | 4 , 2 , 2 | 1 , 6 , -5 | 5 , 4 , 1 |
| Kerala | 2 , 10 , -8 | 1 , 9 , -8 | 9 , 10 , -1 | 9 , 14 , -5 | 2 , 6 , -4 | 7 , 8 , -1 | 1 , 7 , -6 | 5 , 7 , -2 | 13 , 12 , 1 |
| Madhya Pradesh | 13 , 8 , 5 | 11 , 8 , 3 | 2 , 5 , -3 | 2 , 10 , -8 | 6 , , 6 | 3 , 4 , -1 | 12 , 6 , 6 | 8 , 8 , 0 | 15 , 10 , 5 |
| Maharashtra | 9 , 7 , 2 | 8 , 1 , 7 | 7 , 13 , -6 | 7 , 5 , 2 | 10 , 11 , -1 | 4 , 5 , -1 | 6 , 3 , 3 | 7 , 9 , -2 | 7 , 2 , 5 |
| Orissa | 1 , 9 , -8 | 7 , 6 , 1 | 3 , 3 , 0 | 11 , 12 , -1 | 3 , , 3 | 5 , 12 , -7 | | 15 , 10 , 5 | 14 , 8 , 6 |
| Punjab | 15 , 15 , 0 | 15 , 12 , 3 | 10 , 14 , -4 | 14 , 15 , -1 | , 9 , -9 | 2 , 15 , -13 | 13 , 13 , 0 | 10 , 11 , -1 | 12 , 3 , 9 |
| Rajasthan | 3 , 4 , -1 | 10 , 3 , 7 | 13 , 15 , -2 | 4 , 1 , 3 | 12 , 5 , 7 | 12 , 9 , 3 | 5 , 8 , -3 | 2 , 12 , -10 | 2 , 9 , -7 |
| Tamil Nadu | 6 , 3 , 3 | 3 , 7 , -4 | 14 , 11 , 3 | 5 , 6 , -1 | 11 , 12 , -1 | 6 , 11 , -5 | 2 , 1 , 1 | 4 , 13 , -9 | 10 , 13 , -3 |
| Uttar Pradesh | 10 , 14 , -4 | 13 , 14 , -1 | 11 , 9 , 2 | 12 , 13 , -1 | 9 , 10 , -1 | 13 , 13 , 0 | 11 , 11 , 0 | 6 , 14 , -8 | 9 , 14 , -5 |
| West Bengal | 4 , 11 , -7 | 12 , 11 , 1 | 15 , 12 , 3 | 3 , 2 , 1 | 4 , 8 , -4 | 9 , 14 , -5 | 8 , 10 , -2 | 13 , 15 , -2 | 1 , 1 , 0 |

*Notes*:

- In any given field, the first number gives a state's ranking (in the corresponding industry) for 1992-97; the second number gives the ranking for 1998-2002; and the third number gives the change in these ranking across the two time sub-groups.
- Results could not be obtained for four industry groups, because the production functions for these were not found to be concave. These industries are 17 (Textiles), 29 (Machinery & Equipment), 32 (Radio, TV, & Communications Equipment), & 35 (Other Transport Equipment).
- Some industries were not present in some states at all, for example, Wearing Apparel and Leather industries in Assam. Consequently, the corresponding fields for these are left blank. Furthermore, in a few cases, results could be obtained for a particular industry-state combination for one time sub-group, but not for the other. These are also appropriated reflected.

## 6. Conclusions: A Review of Key Results and Their Relevance

Several issues have been addressed in this paper, and it is important to bring them together in a coherent and cogent manner. First, this study estimates technical efficiency and progress at a greater level of disaggregation than has been attempted before. The key justification for this is the extra insights that can be gleaned about industrial performance than would be possible through using either total industrial data disaggregated at state-level, or industry-level data aggregated at national level. The strategy employed in this paper allows, by industry, a ranking of Indian states' technical efficiency performance. This further allows one to make inferences about relative state performances across industries, and also to create state-wise profiles of industrial efficiency trends.

Second, estimating technical efficiency changes and technical progress, *by industry*, allows us to glean out patterns of industrial performance. These results are evaluated in context of other information derived from official statistics. Several important conclusions are made here: in the decade since reforms, capital-intensive industries have generally become more capital-intensive and labour-intensive industries have become more labour-intensive, but changes in factor-intensities notwithstanding, industry-groups as a whole have increased their GVA (as a proportion of capital). This shows a positive response to changing economic conditions and incentives. However, there does not appear to be a consistent pattern between efficiency performance of industries, and industrial outcomes measured in terms of growth rates or gross value added. A possible conclusions is that industrial growth in the country is driven more by inputs rather than efficiency, with the latter having a trivial impact at best. This is at best a conjecture that would need further empirical investigation, but one that is very important for designing appropriate industrial policy.

Third, summarising the efficiency patterns of industries, *across states*, helps to map out regions of greater strengths in manufacturing relative to those with comparatively poorer strengths in manufacturing. More significantly, these patterns help to validate common perceptions about states. In general, western and southern states far outperform the northern and southern states in efficiency of their manufacturing sectors. Moreover, the better performing states are also typically those reputed to have more pro-business environments and investment climates, while those with relatively poor efficiency are those known for relatively poor education and health standards, and a poor law and order record. The most surprising result is that of Punjab which, contrary to all expectations, is the worst performing state in the country in terms of manufacturing efficiency. Its position worsens even further as the post-reform decade progresses.

Finally, and most importantly, this paper highlights several areas for future meaningful research. The time period considered for this paper, 1992-2002 is itself constraining and dated. Even though technical efficiency does not appear to play an important role in industrial outcomes *in the time period considered*, it does not mean that it will not assumed greater importance in the future. In fact, it is reasonable to assume that the low initial base would mean that inputs themselves can drive growth, but as the industries mature out, technical efficiency will assume greater importance. Any subsequent analysis (based on more updated data) that validates this assertion will make an important contribution for the development of policies to drive sustained industrial growth. With increasing relevance of technical efficiency, industrial geography will also become more important, i.e. how the industrial landscape of states are transforming over time. An *a priori* expectation is that some heavy and light industries will gravitate towards certain states, based on the latter's industrial and socio-economic policies, and other factors relating to natural endowments and comparative advantage. In other words, specific industries will gravitate towards specific states precisely because of the efficiency advantages provided by the policies and other factors. A better understanding of these patterns will help further understanding of each state's relevant strengths, and allow them devise policies that capitalise on those strengths.

# Appendix

## *Appendix 1: Industry Codes and Names*

### Legend Table: Industry Codes and Names

| Industry | Industry Name |
|---|---|
| 15 | Food and Beverages |
| 16 | Tobacco |
| 17 | Textiles |
| 18 | Wearing Apparel/Fur |
| 19 | Leather |
| 20 | Wood Products, except Furniture |
| 21 | Paper & Paper Products |
| 22 | Publishing, Printing, Recorded Media |
| 23 | Coke, Refined Petroleum Products, Nuclear Fuel |
| 24 | Chemicals and Products |
| 25 | Rubber and Plastic Products |
| 26 | Other Non-Metallic Mineral Products |
| 27 | Basic Metals |
| 28 | Fabricated Metal Products, Except Machinery and Equipments |
| 29 | Machinery and Equipment |
| 30 | Office, Accounting and Computing Machinery |
| 31 | Electrical Machinery and Apparatus |
| 32 | Radio, TV and Communication Equipments |
| 33 | Medical, Precision and Optical Instruments, Watches and Clocks |
| 34 | Motor Vehicles, Trailers and Semi-Trailers |
| 35 | Other Transport Equipment |
| 36 | Furniture |

## *Appendix 2:*
## *Creation of Capital Stock Series Using Perpetual Inventory Method (PIM)*

The specific methodology used in this paper for computing the capital stock is based upon the perpetual inventory method, and is adapted from Goldar (2004). Specifically, the value for capital in any given year *t* is derived using the formula

$$I_t = (B_t - B_{t-1} + D_t) / P_t$$

where $B_t$ and $B_{t}$-1 are the book values of fixed capital in years *t* and *t–1*, respectively. $D_t$ is the reported depreciation, and $P_t$ is the deflator for capital. The implicit deflator for capital, with 1993-94 as the base year, is derived by dividing the nominal series for gross fixed capital formation (GFCF) by its corresponding real series, both of which are available from the website of the Reserve Bank of India.

The initial value of capital (i.e. for 1990, for getting the value of capital for 1991) for each industry was calculated using 2-digit industry data from the Annual Survey of Industries. To do so, the real values of GFCF (for each 2-digit industry group) were taken for the years 1979-80 to 1990-91. Depreciated values for these were then computed, using a rate of 5%, and the formula

$$DGFCF_t = RGFCF_t + (RGFCF_{t-1} * 0.95)$$

where $DGFCF_t$ is the *depreciated* real GFCF in year *t*, $RGFCF_t$ is the real GFCF in year *t*, and ($RGFCF_{t-1}$ * 0.95) is the *depreciated* real GFCF in year *t-1*. A careful analysis of this formula shows that the *depreciated* real GFCF in any given year includes cumulatively depreciated values of GFCF in *all* previous periods. For example, the GFCF value for 1982-83 would include the GFCF values both for 1981-82 and 1980-81, multiplied by 0.95 and $(0.95)^2$, respectively. The value GFCF thus derived for 1990-91 was taken as the initial capital stock for each industry. It was this value that was further divided amongst states, with the weights obtained by dividing the State Manufacturing GDP by Total Manufacturing GDP in 1991-92 (the first year of the sample).

## *Appendix 3:*
## *Consistency restrictions and tests*

The empirical framework used in this paper formulation allows for testing of several things, including standard regularity conditions from production theory. The following specific restrictions were imposed and/or tested:

*Symmetry conditions*: $\beta_{mn} = \beta_{nm}$

where *m* and *n* give all cross combinations of inputs.

*Constant returns to scale* can be testing by imposing the following restrictions:

$$\beta_{l} + \beta_{k} + \beta_{m} + \beta_{e} = 1$$

$$\beta_{ll} + \beta_{lk} + \beta_{lm} + \beta_{le} = 0$$

$$\beta_{lk} + \beta_{kk} + \beta_{mk} + \beta_{ek} = 0$$

$$\beta_{lm} + \beta_{km} + \beta_{mm} + \beta_{em} = 0$$

$$\beta_{le} + \beta_{ke} + \beta_{me} + \beta_{ee} = 0$$

*Whether the underlying production function is Cobb-Douglas*: Testing joint significance of coefficients of *all* cross-multiplications terms involving inputs, i.e. setting all

$$\beta_{mn} = 0$$

Finally, if it is proved that the production function exhibits CRS, then testing for the Cobb-Douglas restrictions is equivalent to testing for *global separability of inputs*.

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