Looking beyond the methods: Productivity Estimates and Growth Trends in Indian Manufacturing

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Abstract

Studies on Indian manufacturing have been unable to provide consistent estimates of productivity and its growth rates. This paper performs detailed and exhaustive set of accounting exercises for the period 1970-2003 using production function, index number and envelopment analysis methods. TFP growth rate average is 1.1% for both gross output based and net value added based measures. In gross output production, share of materials is 0.6, much larger than the capital and labor shares. Share of capital is constantly increasing. For the period just after the reforms (1991-1997), input growth jumps but TFP growth is negative. But after 1998, the trend reverses and output grows slowly despite negative input growth due to large TFP growth. Aggregated TFP growth rates (Domar-weighted and Fisher index) also follow the same pattern; showing upward trends after mid-1990s. There are no significant differences in TFP growth rates among different-sized firms. After the reforms, TFP growth increases substantially in the public corporations. Productivity transition seems to be random across different (3-digit NIC code) industries. Industries with focus towards services experienced higher productivity growth than others. These results show that the lack of productivity growth was the reason for unimpressive performance of Indian manufacturing earlier.

Keywords:

Productivity Growth. Indian Manufacturing. Tornqvist Index. Reallocation. Envelopment and Frontier Analysis. Value-Added. TFP Decomposition. Domar Aggregation.

JEL Classification:

B41, C43, D24, D45, J08, L6, M41, O4, O47, O53.

1 Introduction

This paper is about studying the performance of Indian manufacturing industries between 1970 and 2003. These have been very interesting and transforming years for aggregate Indian economy. Has it been the case with Indian manufacturing as well? The answer is not clear. Research studies are in plenty, but no consensual picture has emerged in the literature. The reasons for these vary from poor data availability (until recently) to debate about accuracy of different measures, deflators and accounting methods. Hulten and Srinivasan (1999) [17] summarize the scenario by stating "this is an area where tyranny of numbers has asserted itself with great force" and rightly so.

This has been hampering many other streams of research like effect of reforms or economic growth. Because any discussion, on why the growth in Indian manufacturing was lower than Chinese manufacturing or service sector in India, requires robust and reproducible estimates of growth rates and period-wise trends. But various studies on Indian industry, despite using the same dataset, have come up with very different growth estimates.

To be fair the argument is sometimes about which methodology to use, but data quality specially the confusion regarding the deflators makes the situation worse. Goldar (1986) [15] estimated TFP growth to be be around 1.2 per cent per annum. Ahluwalia (1991) [1], however, observed a decline in total factor productivity (TFP) at the rate of 0.3 per cent per annum over the period 1965-66 to 1979-80. Goldar (1995) finds the total factor productivity growth for the organized manufacturing sector to be 1.55 percent per annum over the period 1970-71 to 1980-81 which rises to 3.85 per cent during 1980-81 to 1985-86 and further to 5.05 per cent per annum during 1985-86 to 1990-91. Later studies contradict this and find that TFP growth in 80s was lower than these estimates. Goldar (2002) [14] tabulates TFP growth estimates from few studies. Estimates vary between -1.2% and 3.4% per annum for 1980s and between -0.3% and 5.5% per year for 1970s, which is not very helpful.

How much did the Indian industry grow in different periods? Did the growth occur due to input growth and TFP growth? How is this growth distributed across industries and across public vs. private sectors? What has been the share of labor and capital in the production and how has it changed during various stages? How has the productivity growth transitioned? If we aggregate over all industries, what are the trends in input, output and TFP growth rates? These are the questions this paper answers; providing an exhaustive set of estimates both in terms of productivity measures and growth analysis methods.

This paper applies various techniques to the recently released Annual Survey of Industries dataset for the period between 1970 and 2003 to document a comprehensive set of productivity and growth estimates. The paper calculates growth rates using traditional accounting, index numbers and stochastic frontier/ data envelopment analysis. The objective of this data mining exercise is to find trends and patterns that are robust to estimation technique used. The paper also compares the results from various methods and discusses why they are different and (more importantly) what these differences imply. Use of standard methods as outlined in OECD productivity manual (2001) [12] makes the estimates in this paper not only more accurate, but also more comparable with estimates from studies on other countries including developed countries.

Registered manufacturing in India experienced growth of gross output at annual average of 6% between 1970 and 2003 and net value added grew at average 4.2%. But most of this growth was due to input growth (including materials/ intermediate inputs) and TFP growth on average was only 1.1% per year. Period-wise growth trends provide interesting insights; with output measures growing at steady rate until after the reforms. For the period 1998-2003, growth rate averages for gross output and net value added are only 3.2% and 0.6% respectively. This has been misconstrued by many researchers as reforms having undesired effect of slowing the growth, while in fact the opposite is true. Between 1998 and 2003, both capital and labor input growth average is negative (-3.9% and -3.7%). So despite this lower input usage the output grew because of the increased TFP growth which is estimated to average around 2.3% for gross output based measures and 4.8% for net value added based measures.

Another very interesting result is about the role of intermediate inputs. Single factor productivity growth rate average is negative for materials, indicating that other factors like labor were being utilized in a way that lowered the output per unit of material used. Gupta (2008) [16] finds that it is the distorted use of materials that results into lower productivity growth in Indian manufacturing before the reforms.

Two points are noteworthy about previous studies on Indian manufacturing. It seems that researchers are reluctant to use index number techniques and most of them still prefer primal decomposition using production function. In developing countries where market mechanisms do not work smoothly, prices and accounting for price changes become important because of changing factor shares. This is especially relevant for India where reforms have been undertaken in different phases.

The labor cost to value added ratio has fallen from 0.6 in 1971 to around 0.3 in 1999. This kind of transition due to changes in policies and/or production technologies, makes the estimates calculated using traditional growth accounting methods erroneous. TFP growth rate averages are overestimated by as much as 100%.

Another important point missing from the discussion is acknowledgment of the fact that these methods rely on different assumptions (e.g. perfect competition, constant return-to-scale, functional form, distribution of technological shock) and hence the estimates are not likely to be same. In fact many of the contentions, like gross-output vs. value-added or which deflator to use, have already been addressed in OECD manual [12].

Using panel data for 58 industries, the paper compares the estimates using same deflator and sector-specific deflators. The differences are very large, which makes a case against using approximation and explains why researchers argued back-and-forth regarding the TFP growth estimates. Since computation technology is no longer a bottleneck, there should not be a trade-off with accuracy. Central Statistical Organization publishes the price indexes for most of the industries and this paper uses those specific deflators to calculate the productivity growth estimates.

Aggregate production technology of Indian manufacturing is estimated using Cobb-Douglas, CES and Translog functional forms. One of the issues with production function estimation is that input allocation is affected by productivity signals that are observed by firms' managers but not by econometricians. Levinshon and Petrin (2003) [18] and Olley and Pakes (1996) [20] solve this problem by using materials and investment as proxies to separate the effect of observed technology on input allocation. The paper uses both methods and finds robust estimates for the share of labor and capital. For the production function of net value added, capital share is around 0.4 while labor share is 0.45 when using Levinshon and Petrin estimation and 0.54 when using Olley and Pakes estimation. The paper also applies these estimation techniques to period-wise subsamples. The results show that capital share is really low in 70s and increases in later time periods. Estimates for gross output production function are interesting. For Indian manufacturing industries, materials or intermediate inputs are the most important factor. Its share is estimated to be around 60% and it is similar in all sub-periods.

The paper also compares the productivity and its growth rates across organization types and ownership types. State-wise comparison has been the focus of most of the research, but the structure and characteristics of the firm (decision making unit) itself should have more profound effect on production process and its efficiency than state government policies. Bartelsman and Doms [3] argue that evolution of productivity growth depends on ownership and management. Paper finds that both TFP growth and non-parametric technical efficiency improvement is highest in public corporations and local government owned firms. This seems surprising at first, but seeing the efficiency movement graphs shows that these public corporations and local government owned firms are relatively very inefficient to begin with. These become equally efficient to partnership, private limited and privately owned firms over time. This indicates that TFP growth represents the effect of reforms rather than shocks or changes in production technology. Another thing to remember in this context is the sale of public sector firms under disinvestment initiative in 90s. Higher TFP growth rates of public corporation may be measuring this improvement in average quality of firms due to the sale of the sick units. I also study the distribution of TFP growth rate by firm size measured as number of workers. The estimates dismiss the theory that small scale industries are responsible for low TFP growth rates. Period-wise and overall averages of TFP growth rates do not depend on firm size.

I calculate TFP growth decile of industries and changes in it over time to study the productivity dynamics. This approach is similar to the one in Bartlesman and Dhrymes [7]. The paper finds that none of the industries are always better or worse performing relative to others. The distribution of improvements in relative performance in terms of TFP growth rate does not differ much between 1970s and 2000s. This result goes against the explanation that only some of the industries performed well and others did not, which made overall growth slow.

This paper does another first by applying aggregation techniques like Domar weights and Fisher quantity indexes to Indian manufacturing data which are common in productivity analysis literature of developed countries. It also studies whether there are any gains from reallocation due to factor movements and demand shift between industries. Paper finds that both capital and labor moved to industries which on average experienced lower TFP growth. This is in contrast to the fact that demand (as measured by output share) increased for the industries who experienced higher TFP growth. This result supports much talked about labor inflexibilities and hiring costs. So increased labor ends up triggering these inefficiencies. These inefficiencies show up as reduced TFP growth rates. Aggregated TFP growth for the entire period is estimated around 1.9%. Period-wise trends again show an upward transition around mid 90s; highlighting the positive impact of reforms.

In following sections, I give brief description of data and distinction between the methodologies. The rest of the paper then discusses these results in details. These results are organized in four sections: all-industries, panel analysis, growth distribution and aggregation.

2 Indian Manufacturing Data

The paper uses data from Annual Survey of Industries to calculate productivity and TFP growth rates using various methodologies. This second edition of dataset was released by Economic and Political Weekly Research Foundation in April 2007.

The ASI extends to the entire country except for the States of Arunachal Pradesh, Mizoram, and Sikkim and Union Territory of Lakshadweep. It covers all factories registered under Sections 2m(i) and 2m(ii) of the Factories Act, 1948 i.e. those factories employing 10 or more workers using power; and those employing 20 or more workers without using power.

The dataset has 31 principal characteristics like gross-output, net-value-added, workers, fixed-capital etc. for time period between 1973 and 2003. The paper uses both All Industries data and 3-digit industry code data (58 industries). Most of the series I use in this paper are taken directly from the dataset or derived from it.

Industry-specific price deflators are taken from the whole-sale price index series provided by Central Statistical Organization. GDP, GDCF deflators and interest rate (for missing years) series are available from Handbook of Statistics of Indian Economy, Reserve Bank of India.

Other details about ASI database and notes on various series creation are mentioned in appendix 8.

3 What do accounting methods measure?

National accounts and productivity estimation using that data should be a straight forward exercise based on standard methods. But regrettably there exists a disconnect between statistical agencies and research community. Agreement on System of National Accounts (1993) [19] and the release of OECD productivity manual (2001) [12] has not helped in reaching a consensus on which methods and which measures to use for analyzing the productivity growth. This is specially true for studies on Indian manufacturing. Confusion arises from different measures and methods resulting in different estimates, which are then defended by contentious arguments in favor of and against various measures and methods. In this paper, I use two measures of output; gross output and net value added. In manufacturing context and at industry level these two represent different economic quantities. Gross output is the value of the output of production process while net value added is the difference between value of the output and the value of intermediate inputs. Intermediate inputs like materials, fuels etc. are very important for production in manufacturing sector. Ideally the estimated growth rates of these two output measures should be similar, but Indian manufacturing had many restrictions in form of license/ permit system and quantitative quota etc. These restrictions distorted the intermediate input usage complicating the productivity growth analysis.

Both sets of estimates have different uses. Gross output based productivity growth estimates include the effect of efficient (or inefficient) usage of materials. On the other hand, value added based productivity growth estimates are easily comparable across industries because these do not depend on scale of operation. For example shoe manufacturing and petroleum refining might have huge difference in gross output just because of the differences in value of intermediate inputs used (leather and petroleum respectively). Comparing per-worker productivity based on gross output does not make sense in this case and we should use net value added based measures. As the paper shows in the later sections, growth rate averages are more than twice as high using gross output measures compared to value added based measures. The difference is due to accounting for changes in intermediate input. Gross output based measures being higher means that there are positive gains from improvement in intermediate input usages.

The above distinction between gross output based and net value added based growth rates is valid for single factor as well as total factor productivity measures. Single factor productivity growth rates include growth in output or value-added due to increased and better usage of other factors. Interestingly for materials or intermediate inputs, the estimated average single factor productivity growth rate is negative. This points that labor and capital allocation changes are negatively affecting the materials usage in production process.

This paper covers another dimension regarding productivity estimates and that is which accounting methodology to use. Traditional growth accounting and index number approach rely on functional form, while data envelopment and frontier analysis methods are non-parametric. Growth accounting estimates the productivity growth rates by decomposing output growth into input growth and residuals using Cobb-Douglas production function. The method is simple but estimates depend hugely on the factor shares used. It does not account for movements in factor share over time. This is a problem because labor share has been falling in India and capital share is increasing. Using the indexes of input and output quantity growths and estimating TFP growth rates using these takes care of the changes in share if we are using Fisher or Tornqvist index. Tornqvist index is exact to translog function which is a flexible functional form and approximates actual technology up to second order. So the dependence on parameter values is not an issue. Paper finds that the point estimates are different using growth accounting (constant share) and index numbers. Some of the growth which is due to change in factor importance shows up as TFP growth in traditional growth accounting, making the estimates higher than more accurate index number estimates. But a closer look at period-wise trends shows that both set of estimates move similarly experiencing a drop in TFP growth rate in early 90s before picking up in mid 90s. Non-parametric estimates are closer to index number estimates than growth accounting estimates. But these technical efficiency and scale efficiency growth rates have different interpretation than estimated TFP growth rates. As earlier, the trends in growth rates of envelopment and frontier estimates are similar to trends in TFP growth estimates obtained using index number and growth accounting.

4 All Industries: Results

I start with estimating input (capital, labor and materials) and output growth rates for all industries. There is much disagreement in the literature regarding this simple accounting and it pertains to whether net-value-added or gross-output represents the true output growth and how to properly deflate. Gross output and net-value-added although similar at the economy level can be quite different in manufacturing sector. This paper treats gross output as output of production process with capital, labor and materials as inputs; while net-value-added as output of production with just capital and labor as inputs.

For output, growth rates of both measures (gross output and net value added) are calculated. Unlike previous studies which do not account for miscellaneous services as input in production process into account, I obtain the double deflated net-value-added by subtracting the value of materials and fuels, then deflating the remainder (business services input) by CPI and adding the deflated value of materials (by Manufacturing price index) and deflated value of fuel (by fuel,energy and lubricant price index) to it[1]. For capital the paper calculates the user-cost[2] as outlined in OECD productivity manual [12] and Diewert (2003) [9].

I also calculate growth rate of net-value-added using single deflation for comparison. This is to highlight the contention in the literature about earlier studies which used single deflation method.

[1] I also recalculate the net-value-added growth rate estimates using value-added deflator index obtained by combining output prices and materials prices. Growth rates differ very slightly and period-wise averages of growth rates are almost the same.

[2] Capital taxes are not considered because of unavailability of reliable series.

Period-wise averages of annual growth rates in input and output quantities are shown in table 1. As Hulten and Srinivasan (1999) [17] point out, output growth rates are not as bad as largely believed. Average of growth rates between 1970 and 2003 (32 years) is 6% for gross output and 4.2% for value-added. But during the same period, labor and capital growth rates have averaged 1.1% and 3.6% respectively. Materials usage itself has grown up by 6.5% which is even higher than the growth rate of gross output.

Most surprising are the estimates for last sub-period, 1998-2003. Contrary to the notion, growth rates in this supposedly more reformed period are lower (3.2% & 0.6% respectively) compared to 1991-97 period and even growth rates in 70s and 80s. The reason for this seemingly dismal performance between 1998-2003 is lack of input growth. Growth rate average for both capital and labor inputs are around -4%. If growth in input accumulation was important for growth of Asian tigers and thus motivation for introducing capital market reforms, it certainly does not seem to be happening in Indian manufacturing. This might be because the base capital stock has become too large over time and new capital formation can not keep pace. Another reason might be creation of Department of Disinvestment to sell off the non-performing public sector units which shows up as negative capital growth.

Estimated average growth rates of net-value-added using single and double deflation do not differ by much for entire period. But for 70s and 80s, the trend in growth rates is reversed. Double deflation method implies that growth rate of net-value-added is higher in 70s than in 80s, but estimates become lower in 70s if using single deflation method. I agree with the procedure outlined in OECD productivity manual [12] of deflating both the output and the input with respective deflators to obtain the net-value-added series. Hence single deflation of net value added should not be used unless specifically warranted.

Figure 1 shows the trends (using HP Filter) in these input and output growth rates. Gross output growth rates showed an upward trend in early 70s and have gone down in late 90s. Materials usage growth rates increased a lot in 70s.[3] Interestingly, drop in capital growth rates seem to happen just after reaching a peak in early 1990s when the capital markets reforms were undertaken. The capital growth rate has gone down ever since. Labor growth rate has been continuously decreasing.

The paper calculates two sets of productivity estimates, one for gross output and value-added each. Labor productivity is defined as output per worker. Similar definitions are used for capital and material productivities.

[3] These are trends in growth rates and hence even a (positive) constant trend means that the series is growing.

For TFP estimates, I use following three methods.

1. Growth Accounting: I assume Cobb-Douglas specification with Hicks neutral technical change parameter.

2. **Index Number:** As the paper shows later, factor shares in Indian manufacturing are changing over time. This is why it is better to use Index number approach for TFP estimation. Not many of the papers use this technique. I calculate total factor productivity index as ratio of output quantity index and input quantity index.

$$TFP = \frac{Y(p^t, p^{t+1}, y^t, y^{t+1})}{X(w^t, w^{t+1}, x^t, x^{t+1})} \tag{1}$$

   I calculate quantity indexes using Fisher and Tornqvist formulas. Using program written by Coelli [5], I also calculate corresponding transitive indexes.

3. Data Envelopment Analysis: Since above techniques assume a functional form, I apply DEA to all industries input output data, treating each year as different production unit[4]. Both technical and scale efficiencies are estimated.

The results of period-wise average growth rates of productivity measures are shown in table 2 for gross output and in table 3 for value-added.

On average, labor and capital productivity in terms of gross output has grown at 4.9% and 2.5% per year between 1971 and 2003. The estimates for last sub-period (1998-2003) are around 7% for both and that is because output kept increasing even with decreasing input usage. This should make a case that reforms are working and not otherwise. Because even though output growth rates are higher in early 90s, that growth is mostly due to input accumulation. Period between 1998 and 2003 shows impressive (K,L) productivity growth.

TFP growth estimates using all 3 techniques show similar pattern. Interestingly, estimates using non-parametric Data Envelopment Analysis (of

[4]I realize that this approach is subject to the criticism that in each period production frontier itself might be moving. But in that case, the object I am interested in measuring is how much that production frontier has moved in each corresponding year (since there is only one observation per year it will not be possible to define the frontier anyways). I use this technique with panel data as well where it is more applicable. I do it for all industries for the purpose of comparison with other techniques and showing that TFP growth estimated using other techniques is not necessarily coming from technological progress.

Technical efficiency growth rate) and estimates of TFP growth rates using Index Numbers are almost similar, when materials are not used in the accounting. This may be because even though Tornqvist index uses a particular functional form, it is exact for Translog production function which approximates the actual production technologies up to second order[5]. Estimated period-wise averages of TFP growth are different when obtained using growth accounting technique and using index number. The reason again is because traditional growth accounting ignores the shift in factor shares which happened in India.

Figure 2 shows movements of ratio of labor cost to value added and ratio of labor cost to gross-output with time. The changes in these ratios are significant and that should make a case for including index number estimates of TFP growth rate. Treating labor share as constant will lead to higher TFP growth estimates (since during this period labor productivity is higher than capital productivity).

Average estimated average of growth rates for entire period is 4.1% for growth accounting and 2.7% for index number. Which estimates are correct and which is the best technique? It depends on what one wants to measure in the TFP growth. If the objective is to measure everything other than inputs, then growth accounting estimates should be chosen. But if we think TFP should be defined such that it represents only the unmeasurable (including technological progress), then we should account for the effect of price changes as well and use the index number estimates. Technical efficiency measures slightly different variable. It measures how much more efficient production process has become in converting inputs into output. So it is a narrower concept than TFP growth. On average technical efficiency grew by 2.7% per year.

Table 2 also shows estimated averages of TFP grow rates when material is also included as an input to the production process. The estimated averages of TFP growth rates between 1971 and 2003 become lower (less than $\frac{1}{5}$ of original for technical efficiency improvement, 40% of original for TFP growth using index number and 60% of original using growth accounting). One point is noteworthy when accounting with materials. It becomes clear that TFP growth is not coming from technological progress [6]. In 1998-2003 period the TFP growth average is 2.3%.

One of the most important points to notice in table 2 is the growth of materials productivity. It is going down between 1998 and 2003, but this

[5]See Diwert(1976) [8] for details.

[6]Technical efficiency in this setup would roughly correspond to yearly improvement in output using the same inputs which is same as technological progress.

should not be interpreted as rise in inefficiency. In fact exactly opposite is happening. Removal of quantitative restriction means that after reforms firms operating at sub-optimal ($\frac{materials}{worker}$) ratio can now increase their material input and reach the efficient allocation. This will enable workers to convert more of intermediate inputs to final goods. And that is what shows up by increased labor and capital productivities in last period.

Results for productivity growth estimates using value-added as measure of output are shown in table 3. This is one of the major issues in Indian manufacturing literature. The estimates of different studies are not same and researchers have criticized others for using the wrong method. The two set of estimates in this paper are not same either. But those are not supposed to be the same. Value-added based growth rates represent a different production setup. It does not take into account the changes in intermediate inputs usage. These two should be similar to gross-output based growth measures if intermediate input is always optimally allocated. But that was not the case in Indian manufacturing.

Between 1971-2003 average TFP growth rate using net-value-added is estimated to be 2.4% (growth accounting) and 1.1% (index number). Again, the last sub-period 1998-2003 shows impressive TFP growth of around 4.5%. These estimates being higher than gross-output estimates reinforces the belief that these gains are coming from how materials are being used. When we don't account for changes in materials usage, they show up as part of TFP growth.

Figures 3 and 4 show trends in these different productivity growth measures. TFP growth was stagnant during 80s. There definitely is a transition and TFP growth seems to be picking up in early 90s. It is same for all three accounting setup (gross output with and without materials; value-added).

I want to stress again on importance of including price changes in growth research even though the objective is to analyze changes in real quantities. The reason is that economy-wide analysis always involves large amount of aggregation and the importance of different commodities/ sectors may change over time. This change contains some meaningful economic information and often represents some gains from substitution between sectors. Ignoring it by assuming the base period shares/ weights is likely to give higher (probably incorrect) TFP growth estimates.

Following Waren, Fox and Kohli [13] who implement Diewert and Morrison [10] decomposition, the paper decomposes the growth of nominal output into growth in netput price index and growth in input quantity index. I treat materials as negative output and estimate equivalent of Terms-of-Trade effect. It is this Terms-of-Trade effect that appears as TFP growth when doing traditional accounting.

Figure 5 shows trends in inflation rates of labor, capital, intermediate inputs and manufacturing output. Netput price index estimating the effect of price changes on Indian manufacturing is shown in table 4. The results show that between 1971 and 2003, price changes are responsible for more than 60% of nominal output growth, while (weighted) quantity growth accounts for only 26%.

4.1 Effect of Firm Characteristics

Most of the studies on Indian manufacturing discuss the growth differences across states. Goldar and Veeramani (2008) [6] find that western and southern states have performed better, while output growth in northern states has not been significant. This paper studies the difference in growth performance not across states, but across organization types and ownership types of manufacturing firms. This approach is based on the argument that productivity should be affected by policies of management which are determined by its organization and ownership type, probably more so than by its geographical location. Goldar, Banga, Renganthan (2003) [4] find significant difference in technical efficiency between private sector and public sector engineering firms.

The results of growth estimation are remarkable both for organization types and for ownership types. Average of TFP growth rates for public corporation is 7.4% and in 1998-2003 period the average of growth rates is astounding 17.8%. Similarly, local government owned manufacturing units experienced TFP growth of average 7.2%. Period-wise averages of TFP growth rates are shown in table 11.

This is an interesting finding and one that might seem contrary to the popular belief that public sector units and government sectors were responsible for lower TFP growth. But in fact it should validate that belief. Because most of this TFP growth in public sector happened after the reforms, while private manufacturing firms did not experience this increase in TFP growth due to reforms. We have to keep in mind that these are TFP growth rates and not the actual level comparison, so if TFP were very low in these government firms to begin with or there were large inefficiencies that were removed during reforms, then it makes sense that public manufacturing firms grew at a faster pace compared to private firms.

Since these growth rate estimates depend on the functional form (Cobb-Douglas) and parameter (factor share), I also use stochastic frontier analysis. I calculate the technical efficiency using production frontier model for both datasets. Estimated efficiencies are plotted by organization types in figure 10 and by ownership types in figure 11. These figures show that efficiency gains are higher in public sector. Private sector's growth estimates are comparatively smaller, but private sector firms were already operating at higher efficiency levels in the starting periods. Results for another widely used technique "Malmquist Index" for organization types are shown in table 12.

I also estimate TFP growth rate by firm-size in terms of number of workers. Period-wise distribution of TFP growth over number of workers is shown in figure 9. There does not seem to be any regular pattern in the distribution. For entire period (1974-2003), TFP growth average is slightly higher (around 3.8%) for medium sized firms (50-99 and 200-499) compared to average of around 2.9% for other sizes except 0-4 workers (1.8% average TFP growth).

5 Panel Data Analysis

In this section, I use dataset on 3-digit industry groups based on National Industrial Classification (NIC) code for years 1973 to 2003. Using this dataset, paper estimates production function for Indian manufacturing. TFP growth rates of various industries are also calculated to find out their period-wise growth trends.

The paper uses industry-specific price deflators (wholesale price indexes) to generate gross-output and net-value-added series and to obtain more accurate productivity estimates. There is much debate in literature about choosing the right deflator. To find whether this is much ado about nothing or whether using specific deflators changes the estimates, I calculate output, net-value-added and TFP growth rates using same deflator and compare the period-wise averages with ones estimated using specific deflators. The results are show in table 5.

Even though one estimate is not always greater than other, for the entire period 1973-2003 the estimated average growth rates of unweighted average (over industry groups) of output, of value added and of TFP is higher when using sector-specific deflators. But this is not true for all sub-periods and there is no reason to assume any systematic relation (under or over) between these two methods. Since sector-specific price indexes are readily available now, these should be used rather than the common deflator.

I estimate two sets of production function. First one is calculated using gross-output with labor, capital and materials as inputs and the second set is calculated using value-added with only labor and capital inputs. The paper estimates Cobb-Douglas, CES and Translog functional forms.

Estimation results of many specifications (with and without industry and time dummies; random, fixed and between effects models) of Cobb-Douglas production function are shown in table 6. As expected, estimated factor shares vary a lot depending on the specification. But in all the specifications using gross-output, material share is the most significant one. This highlights that intermediate inputs are important for Indian manufacturing and should be included in productivity accounting.

Tables 7 and 8 show estimation results for CES and Translog production function. For CES specification, ρ for (L, M) is -1.9. Thus elasticity of substitution between labor and materials is close to -1. For value-added specification, estimated ρ is -0.9, making capital and labor strong substitutes. Estimating Translog function also gives same result regarding the factor share. Material is the most important of the inputs and its share is close to 0.5.

These estimate indicate that for the period under study (1973-2003), intermediate inputs are significant in the production process. Surprisingly and rather unfortunately, their importance has not received enough attention. That is one of the reasons why stagnation of growth in Indian manufacturing has remained a puzzle.

5.1 Simultaneity Bias: Robust Estimates

There are some econometric issues with these production function estimations. Technology shocks or some signals might be observed by the managers of the firm. The input (labor, capital and materials) quantities are decided based on those technological shocks. Hence the production function estimation using simple regression is biased, since unobservables (or a part of it) is related to the input choices. Levinshon and Petrin [18] solve this issue by suggesting a two step process using intermediate inputs as control for observed technological shocks. Olley and Pakes [20] suggest another similar method which deals with additional selection bias using investment as proxy.

The paper calculates estimated factor share coefficients using Levinshon-Petrin and Olley-Pakes methods. Both these procedure still use a functional form (Cobb-Douglas), so I also estimate the stochastic frontier production model with time-invariant technical inefficiency and time-varying decay specifications. To check for structural breaks I run the estimation procedures on period-wise subsamples. Results of these estimations are shown in tables 9 and 10.

Estimates show that importance of capital in value-added (as indicated by its estimated share in production) has been growing over time, with share becoming around 0.6 in last period 1998-2003. This holds true irrespective of the technique used. The result of significance of materials in gross-output production appears again with these robust estimation procedures. The share is again close to 0.5.

6 TFP Growth Distribution and Productivity Transition

What does TFP growth mean? It is a measure of unmeasurable. It includes everything from better management, educated workers, streamlined supply chain to new scientific invention. I think of these TFP growth estimates comprising more of efficiency improvements than technology shocks. When researchers posit about Indian manufacturing not experiencing decent TFP growth, they blame it on market imperfections and not on the lack of industrial research. Production process in manufacturing once set up does not change every year, but one can always become efficient at doing things and that should increase the output even when nothing else has changed. TFP growth represents these gains.

I calculate the TFP growth rates for each industry group. The performances of various industries are very different; with collection, purification and distribution of water experiencing a TFP growth average of 9.8% annually over 30 years, while knitted and crocheted fabric manufacturing industry registered on average a TFP growth of -1.8% per year[7]. Yearly distribution of TFP growth rates is shown in figure 6. We can see that there are some good years (e.g. 1974, 1994) and some bad years (1982, 1993), but the distribution has been changing without any clear pattern.

In figures 7 and 8, I check whether there are any consistent good and bad performing industries (in terms of TFP growth). For each sub-period, I scatter plot start year and end year TFP growth rates in figure 7 and in figure 8 pre-90s and post-90s TFP growth rate averages are plotted. Just like yearly distribution, period-wise industry performance also varies a lot. For example industry "'repair of personal and household goods"' (code-526) experienced TFP growth averaging more than 25% between 1991 and 2003. Average TFP growth for "'Collection, purification and distribution of water"' is more than 10% for both pre-90s and post-90s. But these are the industries which focus more on providing services rather than production or manufacturing of goods using raw materials.

The paper studies the distribution of TFP growth among industries because many of the government policies were sector specific. To find out whether there are any systematic trends in TFP growth, I use Bartelsman and Dhrymes (1998) [7] technique of Productivity transition matrix. For each year, industries are ranked from 1 to 10 based on their TFP growth rates. These ranks (TFP Growth Decile) are plotted in figure 12. It seems that contrary to popular notion that some industries always perform worse

[7]These are averages of growth rates and not the compounded average growth rates.

than others, decile plots show that relative growth performances are very much random. Productivity transition is considered as probability distribution of some industry moving to higher or lower TFP growth decile. This distribution of improvement in ranking or relative performance is indicative of productivity growth and is shown in figure 13. I plot one year transitions for beginning and end of the study-period along with two and three year transitions. Even though the distributions are not exactly similar, there are not many remarkable differences.

7 Aggregation and Reallocation

One of the mechanisms through which productivity improves is factor reallocation. The paper checks whether labor and capital moved from less productive industries to more productive industries. In table 13, I calculate period-wise averages of TFP growth across industries weighted by their output shares, labor shares and capital shares. The paper compares these averages with counter-factual average growth rates obtained using industry-shares fixed at their the base period (1974) shares. I also do similar comparison for labor productivity growth and capital productivity growth. The results are interesting in the sense that counter-factual averages for capital and labor share weighted growth rates are lower than averages using actual shares. It means that overall the labor and the capital did not move into the industries that experienced the higher TFP and productivity growth rates. Since labor share increases are not correlated with productivity growth, it may also imply presence of labor distortions which reduced the productivity growth. Output share calculations present much nicer picture. There are gains from reallocation due to demand shifts between industries. These gains in average TFP growth rate over entire time-period are 30%. We should realize that these are not the exact estimates of aggregate TFP growth rates. There are other better methodologies (e.g. quantity indexes, Domar weights) to calculate the aggregate estimates. But it shows that labor and capital does not move to industries with higher growth rates despite shift in demand towards those industries.

To find the actual estimates of aggregate TFP growth rates, the paper uses both the index numbers and Domar weights techniques. Fisher quantity index for output (and corresponding growth rate) is calculated using industry-specific prices. Labor input is aggregated using industry-specific wages as prices. TFP growth is calculated as the ratio of input and output quantity indexes.

Domar [11] showed how inter-linkage between industries, especially in manufacturing sector where output of one industry acts as intermediate input for some other industry, can lead to aggregate productivity growth being larger than simple weighted sum of individual productivity growth rates. I use Bartlesman & Beaulieu (2004) [2] and calculate Domar weight for each industry using the following.

$$D_i = \frac{(GO)^i}{(GO)^{ALL}} * [\frac{Net}{Gross}]^i * [\frac{Net}{Gross}]^{ALL} \quad (2)$$

Period-wise averages of aggregate growth rates using these methods are shown in table 14. Average of aggregated output and input growth rates are 6.6% and 4.9%. Even after taking care of price differences across industries and over time, TFP growth still accounts for around 25% of the aggregated output growth. Average of TFP growth rate (2%) using Domar weights is close to the one obtained using Fisher quantity index approach (1.8%).

The paper plots the growth trends in these aggregated quantities and estimated TFP growth. These are shown in figures 14 and 15. The change in direction of growth trends of TFP measures is very clear. TFP growth starts going up and the transition is occurring in mid-90s which is when the reforms were undertaken. These trends are consistent with the growth trends obtained earlier using all-industries data.

8 Conclusions

I analyze growth experience of registered manufacturing sector in India between 1970 and 2003. All estimates clearly show positive changes in TFP growth trends after the reform. The paper makes a case for including prices in calculation of growth estimates by using index number approach. Intermediate inputs or materials are significant factor in gross output production function. Any analysis on probable reasons for sluggish performance of Indian manufacturing and role of reforms in promoting growth should look into the materials usage and how it has changed over time. There are indications of labor allocations and movements not being optimal. TFP growth rates of public corporation and local government owned firms are larger, but they were more inefficient to begin with. TFP growth rate is independent of firm size. Aggregate TFP growth has not been remarkable and has averaged around 1.9% during the study-period. TFP growth seems to be coming more from efficiency improvements rather than technology changes.

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Annual Growth Rate (Avg.)					
	1970-2003	**71-80**	**81-90**	**91-97**	**98-03**
Gross Output	6.0%	6.4%	6.6%	7.0%	3.2%
Net-Value-Added(SD)	4.9%	4.8%	6.4%	6.9%	0.1%
Net-Value-Added(DD)	4.2%	6.4%	4.1%	4.6%	0.6%
Labor	1.1%	3.6%	0.4%	2.7%	-3.7%
Capital	3.6%	3.8%	4.4%	8.7%	-3.9%
Materials	6.5%	4.8%	8.8%	6.9%	5.4%
Fuel[a]	5.0%	6.6%	8.5%	3.9%	-2.1%

[a]Unlike materials, fuel is more of an indicator of the production technologies in use than the intermediate input.

Table 1: Growth of Input and Output - All Industries

Annual Growth Rate [a] [b] (Gross Output)					
	1970-2003	**71-80**	**81-90**	**91-97**	**98-03**
Labor Productivity	4.9%	2.8%	6.2%	4.3%	6.9%
Capital Productivity	2.5%	2.6%	2.2%	-1.7%	7.1%
Material Productivity	-0.5%	1.6%	-2.1%	0.1%	-2.2%
TFP^{GrowthAccounting}	4.1% [**2.5%**]	2.8% [**2.4%**]	5.1% [**2.5%**]	2.5% [**1.3%**]	6.9% [**4.2%**]
TFP$^{Index(NonTransitive)}$	2.7% [**1.1%**]	2.9% [**2.4%**]	2.6% [**3.4%**]	-1.5% [**-0.8%**]	7.4% [**2.5%**]
TFP$^{Index(Transitive)}$	2.7% [**1.1%**]	2.9% [**2.4%**]	2.6% [**3.1%**]	-1.5% [**-0.7%**]	7.4% [**2.3%**]
Tech Efficiency^{CRS}	2.7% [**0.5%**]	3.0% [**1.7%**]	2.5% [**-0.1%**]	-1.4% [**0.2%**]	7.2% [**0%**]
Scale Efficiency	2.5% [**0.5%**]	5.0% [**1.7%**]	2.0% [**0%**]	0.2% [**0.1%**]	2.3% [**0%**]

[a]Number in square brackets [ ] are the estimates when material is also included as input.
[b]TFP estimates using Tornqvist and Fisher indexes give similar results. Tornqvist values are shown.

Table 2: Productivity Growth Rates - All Industries

Annual Growth Rate [a] (Net-Value-Added)					
	1970-2003	**71-80**	**81-90**	**91-97**	**98-03**
Labor Productivity	3.2%	3.0%	3.6%	1.9%	4.3%
Capital Productivity	0.6%	2.8%	-0.4%	-4.1%	4.5%
TFP$^{Growth Accounting}$	2.4%	2.9%	2.4%	0.1%	4.3%
TFP$^{Index\,b}$	1.1%	3.4%	0.06%	- 3.6%	4.8%
Tech Efficiency^{CRS}	1.6%	3.4%	0.5%	-2.1%	4.6%
Scale Efficiency	1.3%	4.2%	-0.2%	0%	0.5%

[a]TFP estimates using Tornqvist and Fisher indexes give similar results. Tornqvist values are shown.
[b]Period-wise averages of growth rates in both Transitive and Non-transitive TFP index are same.

Table 3: Productivity Growth Rates (Value Added) - All Industries

Output Growth Decomposition [a]					
	1971-2003	**71-80**	**81-90**	**91-97**	**98-03**
Nominal Output	15.0%	16.2%	16.1%	17.6%	8.0%
Netput[b] Price Index					
Divisia	9.3%	7.6%	11.5%	11.6%	5.7%
Fisher	8.9%	7.6%	10.4%	11.6%	5.7%
Input Quantity Index					
Divisia [c]	4.0%	4.1%	4.6%	9.2%	-3.5%
TFP(Residual)	2%	4.5%	1%	-2.5%	6%

[a]Chain indexes are used.
[b]Intermediate Input is considered as negative output.
[c]Growth rate averages of Fisher index are exactly same.

Table 4: Sources of Output Growth - Diewert Morrison Decomposition

GDP Deflator vs. Sector-Specific Deflators[a]						
		1970-2003	**73-80**	**81-90**	**91-97**	**98-03**
Output	Same	6.9%	9.2%	5.9%	8.4%	4%
	Specific	7.6%	7.5%	7.4%	9.6%	5.2%
Val-Added	Same	5.7%	6.6%	6.2%	7.7%	1.5%
	Specific	6.8%	-3.4%	5.2%	14.3%	8.3%
TFP [b]	Same	2.7%	2.6%	3.9%	1.9%	2.4%
	Specific	3.9%	-7%	3.2%	8.5%	9.2%

[a]UNWEIGHTED mean of annual growth rate over industry panel.
[b]Using Growth Accounting with Net-Value-Added and Cobb-Douglas share of capital as 0.3

Table 5: Difference in Growth estimates - GDP deflator vs. Sector specific deflators

Factor Share[a] in Cobb Douglas (log form)	Capital	Labor	Materials	R^2
Gross Output	0.267	0.219	0.566	(0.9384)
GO with industry dummies	0.429	0.165	0.472	(0.9650)
GO with time dummies	0.247	0.270	0.525	(0.9425)
GO with i & t dummies	0.247	0.386	0.324	(0.9703)
Net-Value-Added	0.46	0.527	-	(0.6969)
NVA with industry dummies	0.711	0.283	-	(0.8089)
NVA with time dummies	0.39	0.592	-	(0.7148)
NVA with i & t dummies	0.262	0.666	-	(0.8272)
GO - Random Effects	0.403	0.174	0.487	(0.9345) [b]
GO - Fixed Effects	0.429	0.165	0.472	(0.9328)
GO - Between Effects	0.229	0.244	0.575	(0.9382)
NVA - Random Effects	0.65	0.367	-	(0.6860)
NVA - Fixed Effects	0.711	0.283	-	(0.6754)
NVA - Between Effects	0.381	0.615	-	(0.6940)

[a]All coefficients are significant at 1% level.
[b]Overall R^2

Table 6: Production Function Estimates for Cobb-Douglas

$lnY = e^{b_0} * [\delta X_1^{-\rho} + (1-\delta)X_2^{-\rho}]^{\frac{-1}{\rho}}$	b_0	δ	ρ	R^2
$Y = GO, X1 = K, X2 = L$	1.39	0.499	-0.598	(0.8675)
$Y = GO, X1 = K, X2 = M$	0.62	0.286	-1.134	(0.9417)
$Y = GO, X1 = M, X2 = L$	0.87	0.402	-1.902	(0.9417)
$Y = NVA, X1 = K, X2 = L$	0.35	0.26	-0.901	(0.7072)

Table 7: Production Function Estimates for CES

$lnY = a_0 + \Sigma\alpha_x.lnX + \Sigma\beta_x.(lnX)^2 + \Sigma\Sigma\gamma_{ij}.lnX_i.lnX_j$	α_x	β_x	γ_{ij}	R^2
$Y = GO, X_1 = K,$ $X_2 = L, X_3 = M$	K: 0.271 L: 0.353 M: 0.526	K^2: 0.043 [a] L^2: 0.044 M^2: 0.088	KL:-0.002[b] LM: -0.090 MK: -0.089	(0.9513)
$Y = NVA, X_1 = K,$ $X_2 = L$	K: 0.27 [c] L: 1.32	K^2: 0.088 L^2: 0.055	KL: -0.172	(0.7087)

[a]significant at 5% level
[b]Not Significant
[c]Significant at 10% level.

Table 8: Production Function Estimates for Translog

Robust(Simultaneity-bias) Estimates					
	1973-2003	**73-80**	**81-90**	**91-97**	**98-03**
Levinsohn-Petrin[a]					
Proxy-M&F	K .39 L .46	K .06 L .57	K .07 L .77	K .34 L .33	K .64 L .24
Proxy-M	K .34 L .43	K .14 L .59	K .25 L .75	K .30 L .37	K .63 L .25
Olley-Pakes[b]					
GO	K .20 L .19	K .05 L .25	K .13 L .26	K .17 L .19	K .2 L .11
	M .63	M .58	M .62	M .6	M .65
NVA	K .41 L .54	K .16 L .66	K .12 L .79	K .33 L .51	K .58 L .36

[a]Net-Value-Added production function is estimated.
[b]Investment is used as proxy.

Table 9: Robust Estimates of Production function and Possibility of Structural Breaks

Non-Parametric Estimates					
	1973-2003	**73-80**	**81-90**	**91-97**	**98-03**
Stochastic Frontier[a]					
GO:TVD	K .28 L .20	K .20 L .63	K .15 L .25	-[b]	-
	M .42	M .07	M .61		
GO:TI	K .41 L .18	K .30 L .72	K .16 L .23	K .2 L .16	K .2 L .04 [c]
	M .48	M .11	M .62	M .65	M .67
NVA:TVD	K .48 L .42	K .26 L .68	K .42 L .51	K .51 L .38	K .59 L .36
NVA:TI	K .66 L .36	K .16 L .68	K .38 L .54	K .57 L .43	K .59 L .36

[a]TVD: Time-varying decay model. TI: Time-invariant model. The idiosyncratic error term is assumed to have a normal distribution.
[b]Does not converge.
[c]Not significant

Table 10: Estimates of Production function - Stochastic Frontier

TFP Growth [a] -By Organization & Ownership					
	1974-2003	**74-80**	**81-90**	**91-97**	**98-03**
Organization Type					
CoOperative	2.2%	-2.9%	9%	1.3%	-0.2%
Corporate	3.1%	1.6%	3.7%	2.9%	4.4%
Individual	1.9%	0%	5.5%	4.6%	-5.1%
Partnership	1.8%	0.8%	3.6%	0.6%	1.2%
PrivateLtd	1.3%	1.5%	1.9%	-1.8%	3.6%
PublicCorp	7.4%	2.8%	6.6%	3.9%	17.8%
PublicLtd	3%	1.5%	4.8%	2.3%	3.5%
UnIncorporated	1.6%	0.6%	3.8%	1.6%	-0.8%
Ownership Type [b]					
CentralGovt	5%	0.6%	7.1%	6.5%	
JointSector	4.8%	1.4%	6.5%	5.7%	
LocalGovt	7.2%	6.6%	2.7%	14.4%	
Private	1.8%	2%	2.8%	0.1%	
StateGovt	3.4%	3.4%	4.9%	1.8%	

[a]Based on value-added, using growth accounting method.
[b]Data is available only up to 1997.

Table 11: Period-wise TFP Growth - By Organization and Ownership Types

Malmquist Index - Mean [a] by Organization Type					
	Eff.Ch.	**Tech.Ch.**	**PureEff.Ch.**	**Sc.Eff.Ch.**	**TFPCh.**
Individual	1.004	0.872	1.000	1.004	0.876
Partnership	0.989	0.928	0.992	0.996	0.917
UnIncorporated	1.005	1.009	1.002	1.003	1.014
PublicLtd	1.001	1.055	1.000	1.001	1.056
PrivateLtd	0.998	1.155	0.998	1.000	1.153
PublicCorp	1.003	1.188	1.003	1.000	1.191
Corporate	1.001	1.269	1.002	1.000	1.271
CoOperative	0.987	1.327	0.999	0.988	1.310

[a]Geometric Average

Table 12: Malmquist Index - Mean by Organization Type

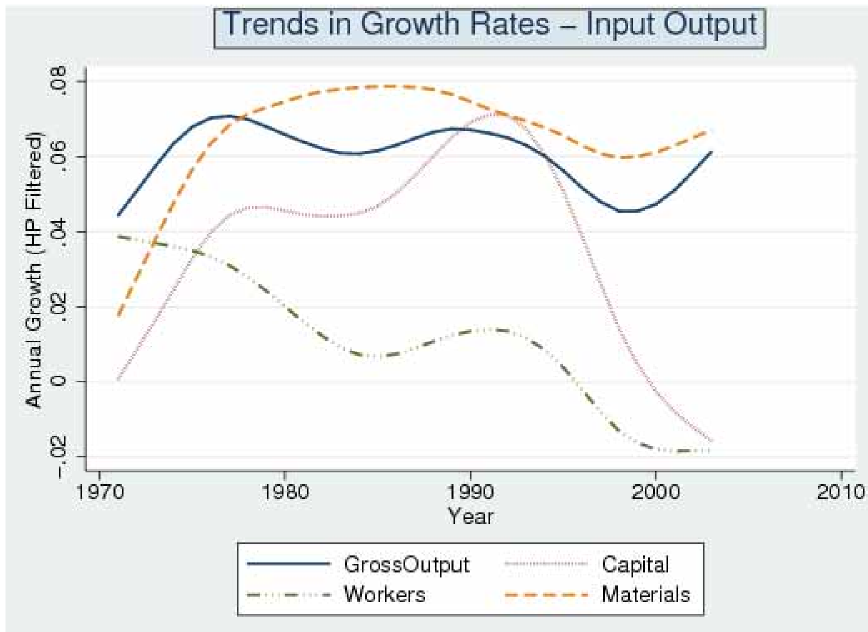
Factor Movements and Demand Shift (among sectors/ all industries)					
	1974-2003	**74-80**	**81-90**	**91-97**	**98-03**
Demand Shift[a]					
TFP	1.9%	2.1%	1.7%	0.5%	3.5%
TFP_{74}	1.4%	1.7%	1.3%	0%	2.7%
Gains					
Labor Share Movements[b]					
TFP	1.3%	1.9%	1.6%	0%	1.8%
TFP_{74}	1.5%	2.0%	1.7%	0.1%	2.3%
Gains					
$(\frac{Y}{L})$	4.3%	1.6%	6.3%	4%	4.4%
$(\frac{Y}{L})_{74}$	4.9%	2%	6.5%	4.7%	6.1%
Gains					
Capital Share Movements[c]					
TFP	1.3%	2.3%	0.5%	0.4%	2.5%
TFP_{74}	1.5%	2.7%	0.7%	0.4%	2.9%
Gains					
$(\frac{Y}{K})$	0.7%	0.8%	1.9%	-1.1%	0.5%
$(\frac{Y}{K})_{74}$	1.8%	1.6%	2.5%	0.1%	2.7%
Gains					

[a]Weighted by Output in each period and in first period respectively.
[b]Weighted by workers in each period and in first period respectively.
[c]Weighted by capital-stock in each period and in first period respectively.

Table 13: Productivity Gains from Reallocation of L, K and Y Shares

Aggregated Growth Rate (Avg.)					
	1974-2003	**74-80**	**81-90**	**91-97**	**98-03**
Output Index	6.6%	6.6%	7%	7.1%	5.3%
(K+L) Index	4.9%	5.2%	4.1%	8.4%	2%
Labor Index	1.3%	3.4%	0.4%	2.7%	-1.3%
TFP Index	1.8%	1.6%	3%	-1.2%	3.7%
TFP Domar-wt.	2%	1.4%	2.6%	1.2%	2.5%

Table 14: Aggregation over Industries - Growth Rate



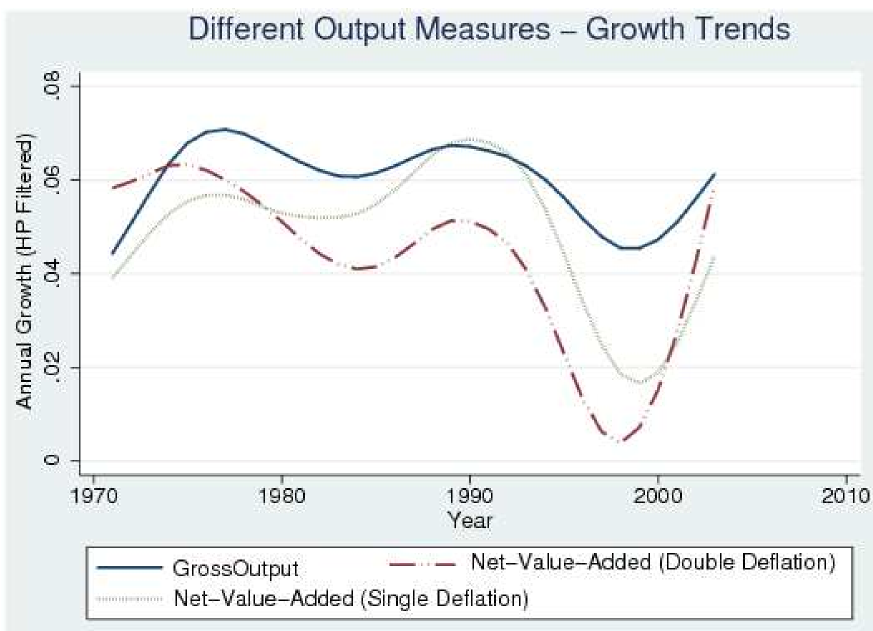


Figure 1: Input and Output Growth Rates - All Industries

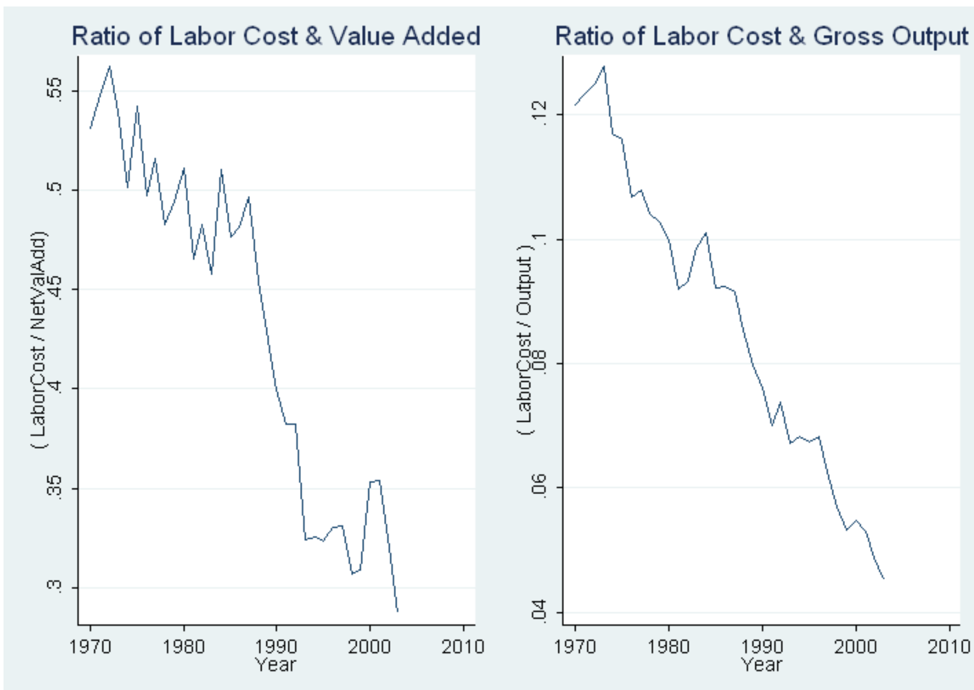
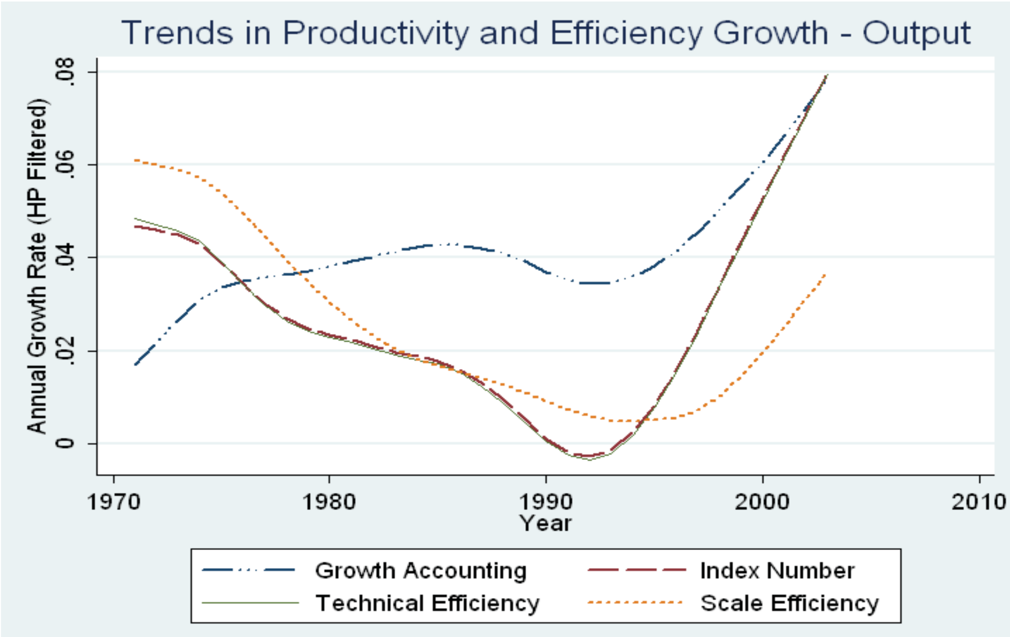


Figure 2: Change in Labor Share



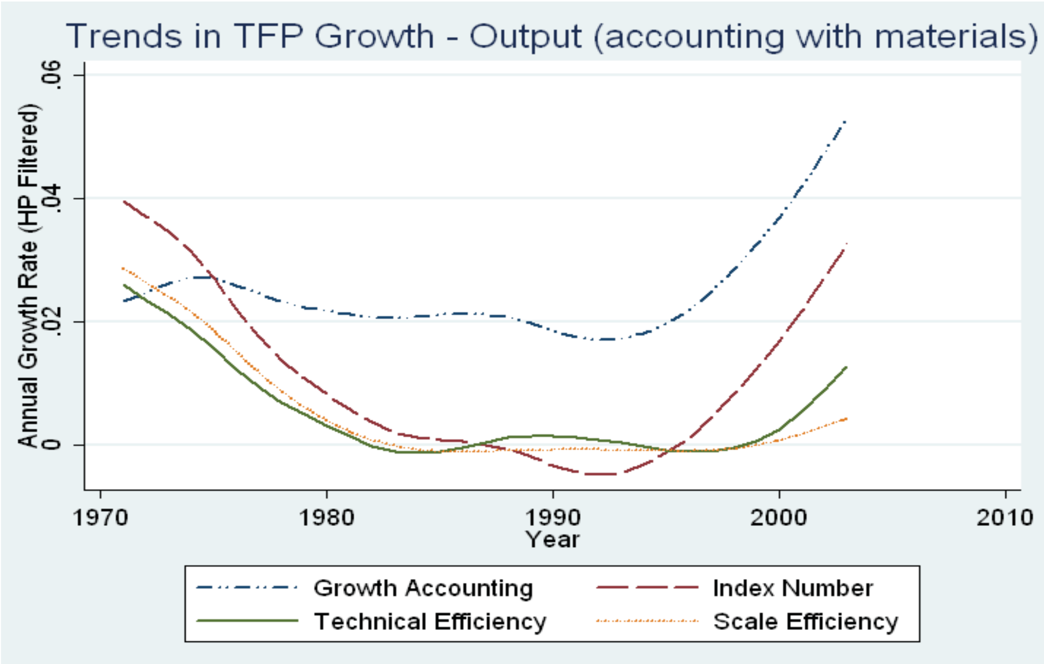


Figure 3: Productivity Growth Trends - All Industries

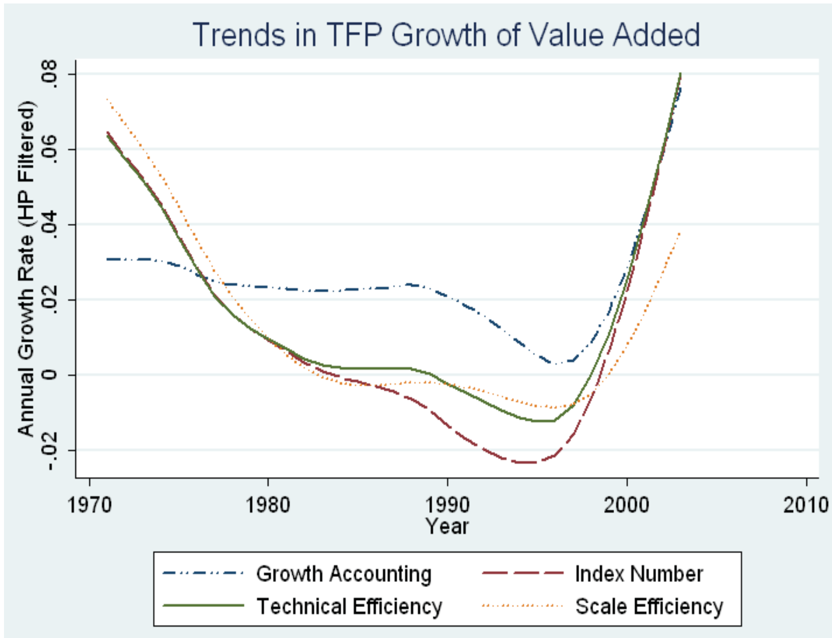


Figure 4: TFP Growth Trends using Net Value Added - All Industries

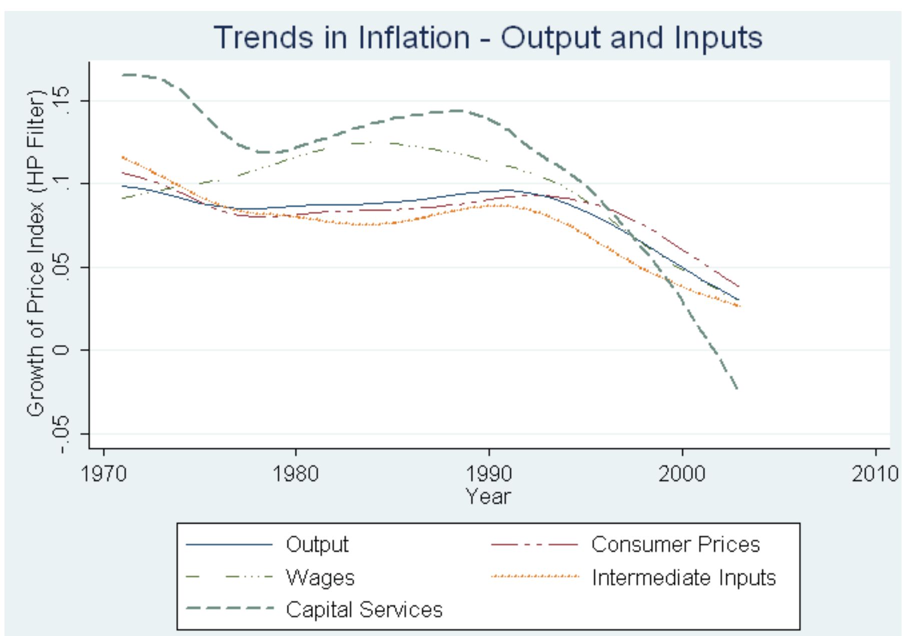


Figure 5: Trends in Input and Output Inflation

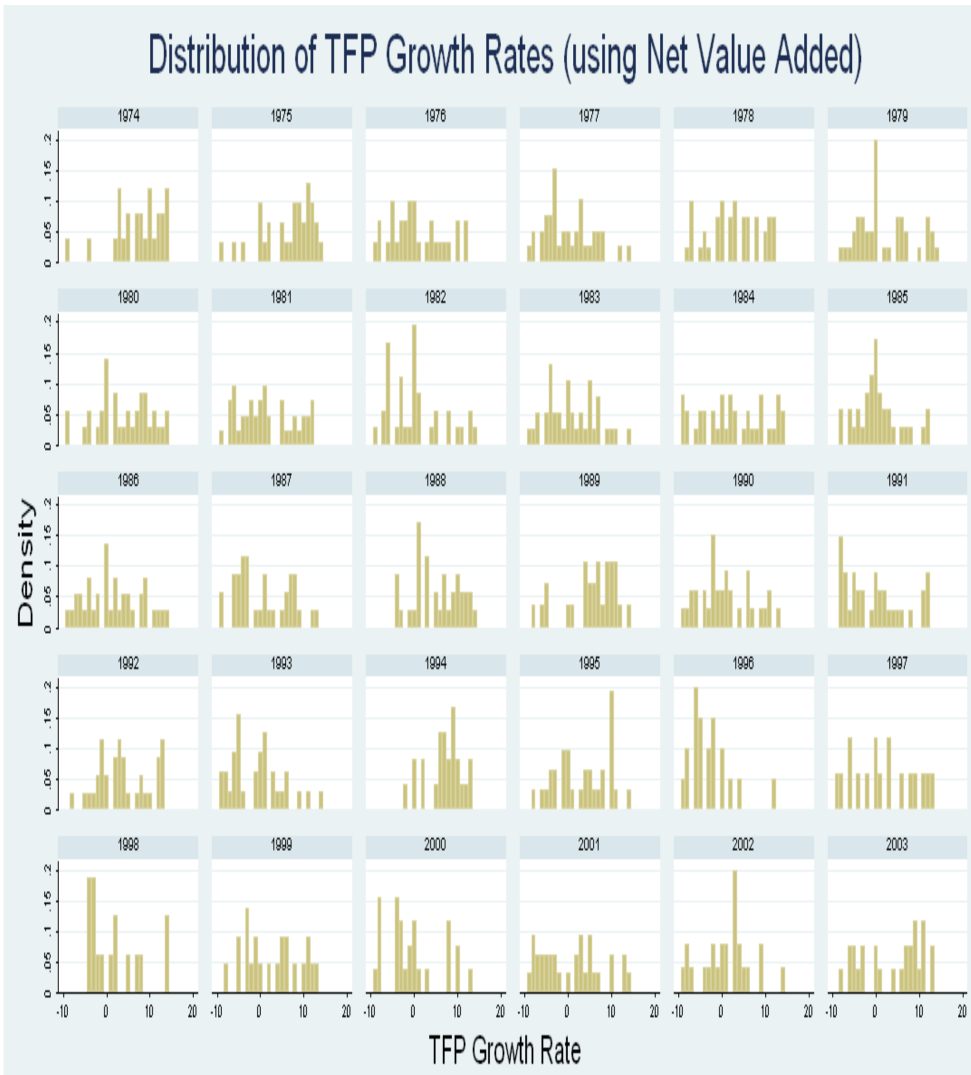


Figure 6: Distribution of TFP growth rates over Time

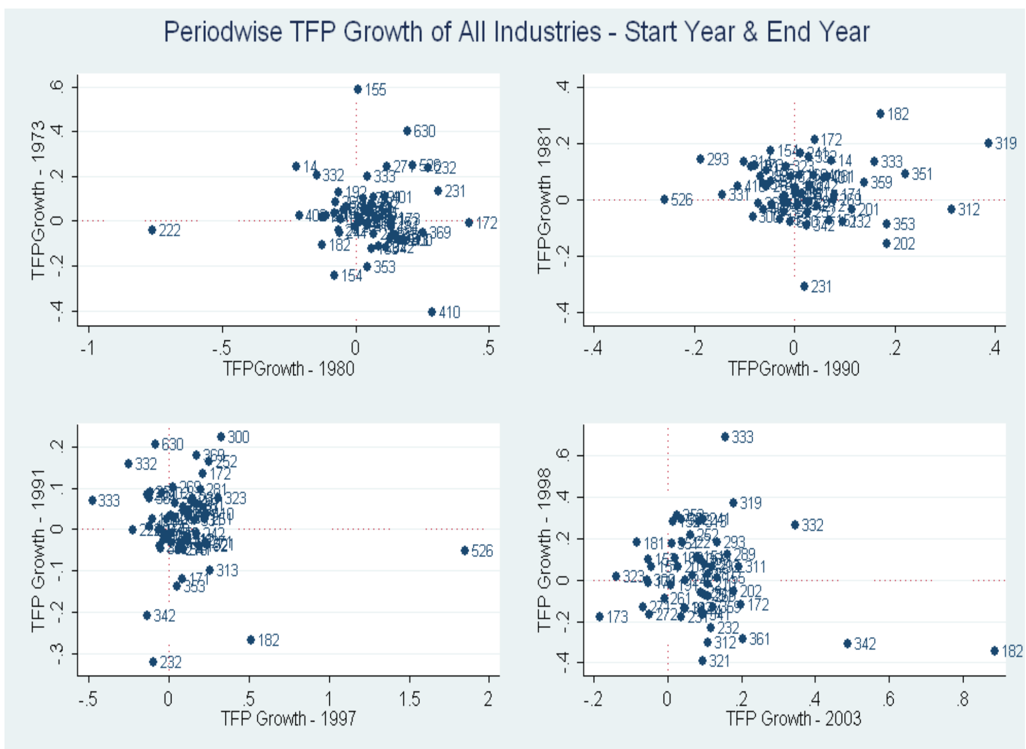


Figure 7: Period-wise TFP growth rate comparison - By Industries

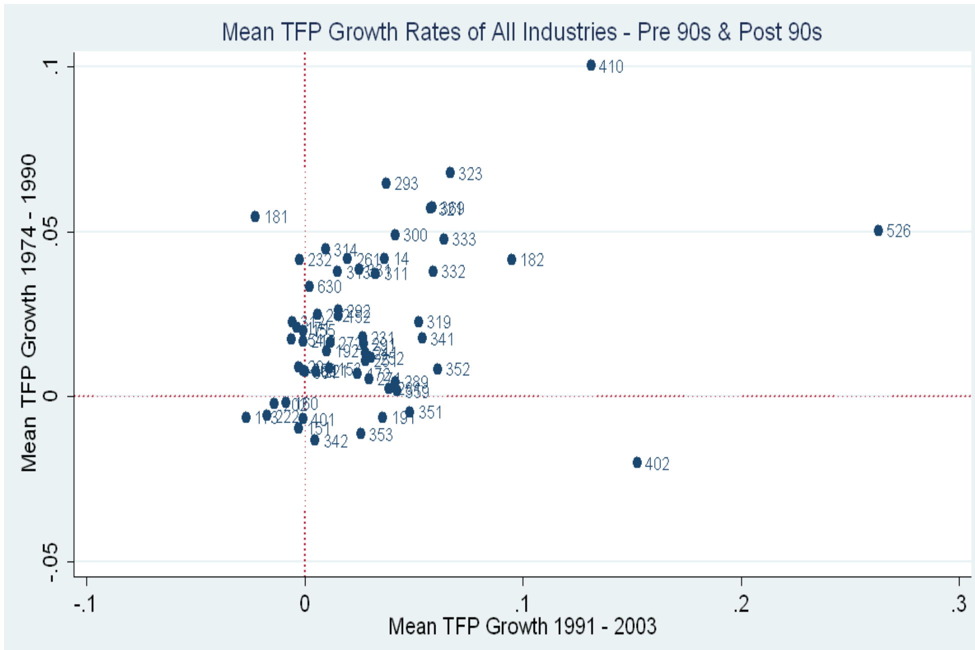


Figure 8: Pre and Post 90s TFP growth rate comparison - By Industries

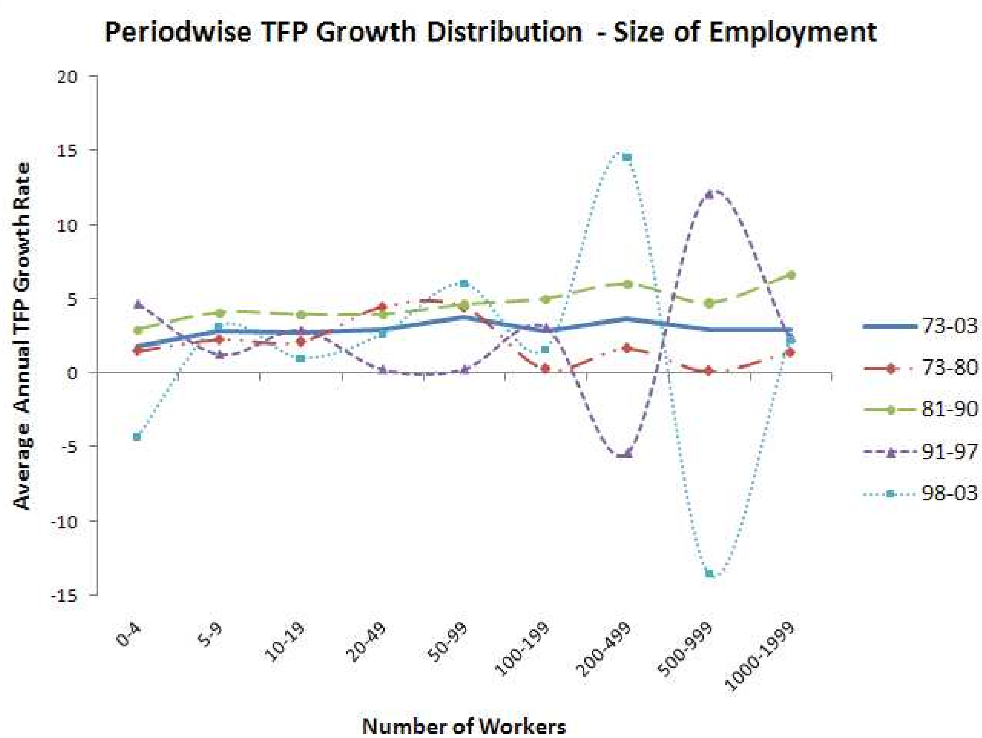


Figure 9: Periodwise Distribution of TFP Growth - By Employment Size

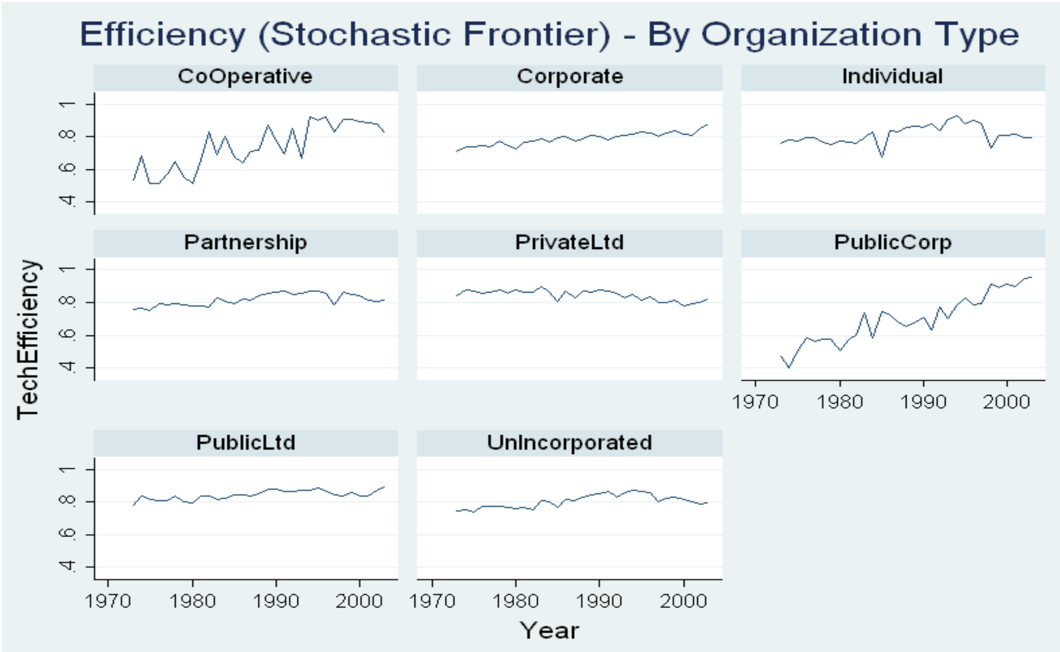


Figure 10: Efficiency Movements - By Organization Types

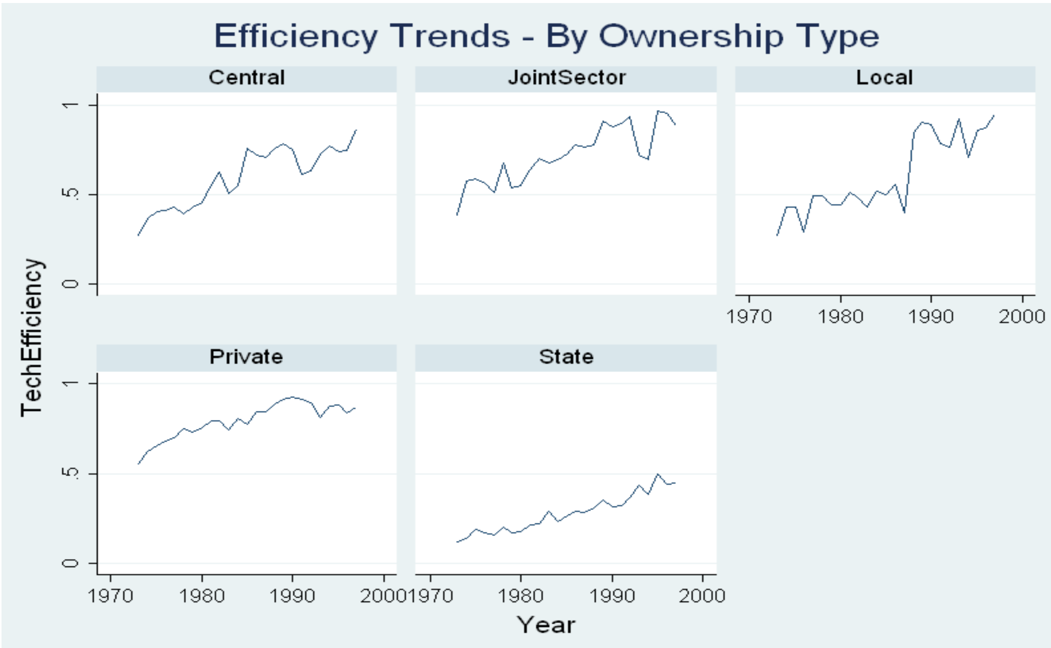


Figure 11: Efficiency (Stochastic Frontier)- By Type of Ownership

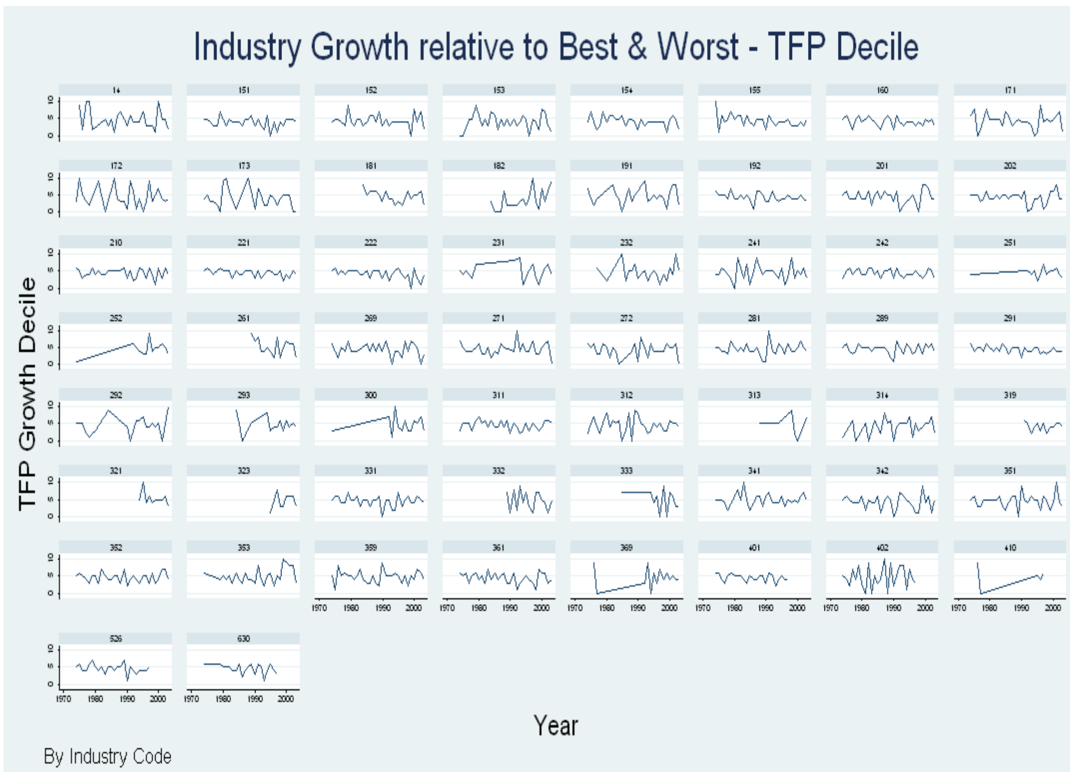


Figure 12: TFP Growth with respect to other industries

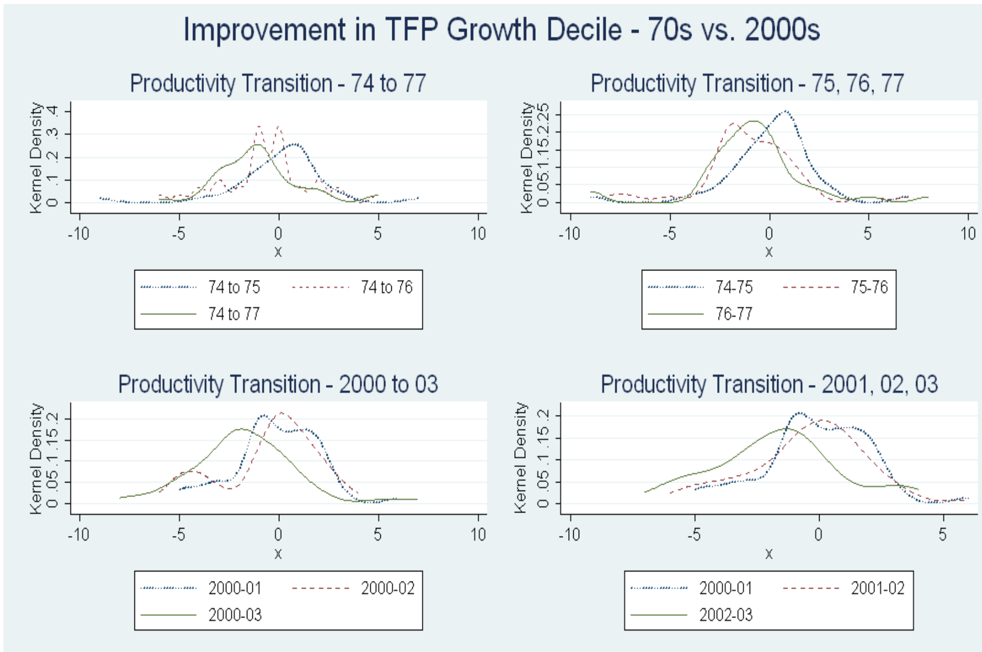


Figure 13: Productivity Improvement - 70s vs. 2000s

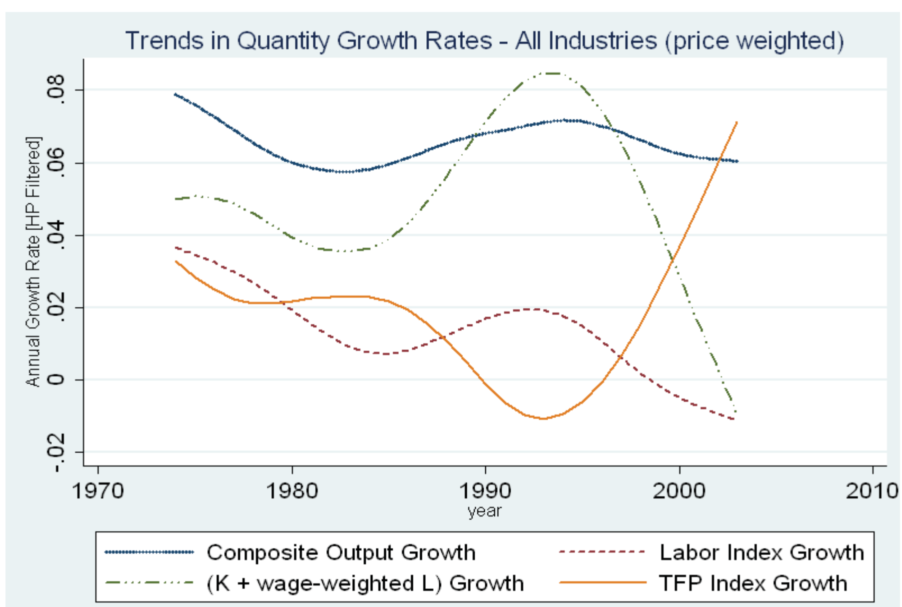


Figure 14: Aggregated Quantities and TFP - Growth Trends

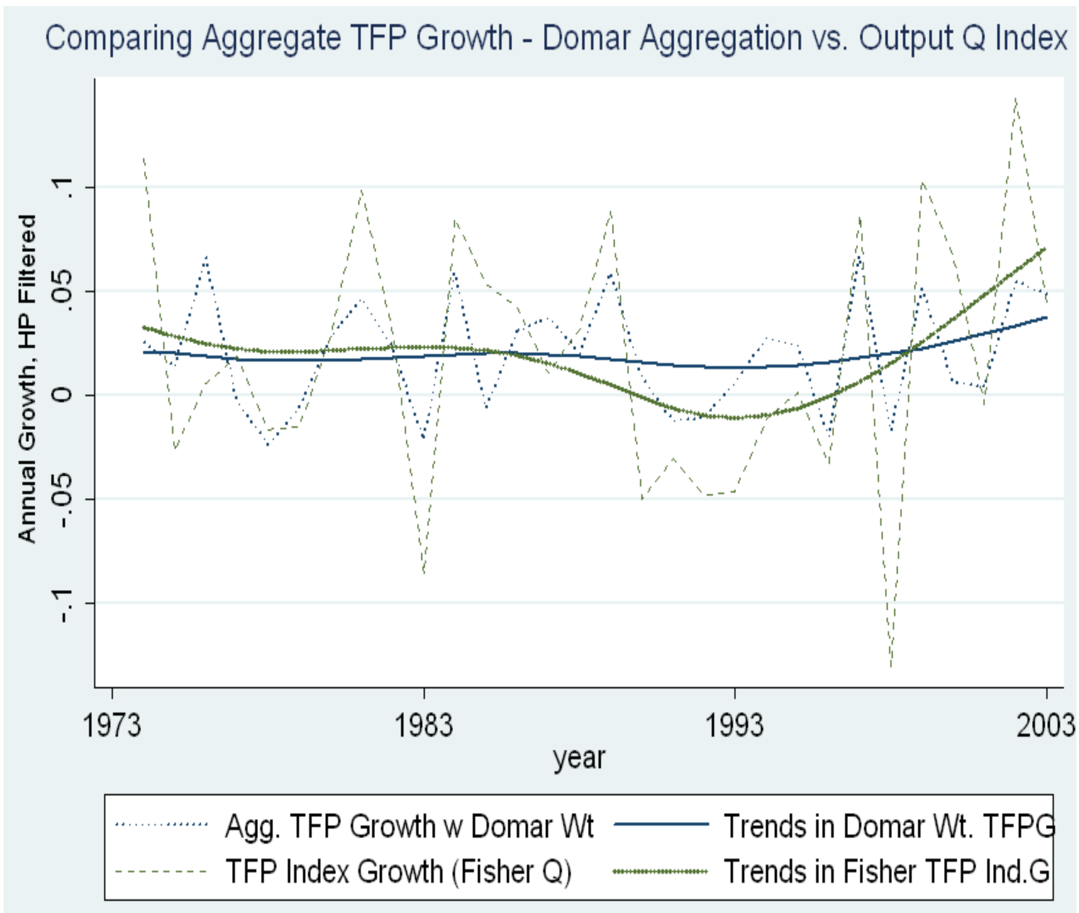


Figure 15: TFPG Aggregation over All Industries - Domar weights vs. Fisher Index

A Notes on Dataset Creation

- **ASI Coverage**
  The survey also covers bidi and cigar manufacturing establishments registered under the Bidi & Cigar Workers (Conditions of Employment) Act, 1966. All electricity undertakings engaged in generation, transmission and distribution of electricity registered with the Central Electricity Authority (CEA) were covered under ASI irrespective of their employment size. Certain servicing units and activities like water supply, cold storage, repairing of motor vehicles and other consumer durables like watches etc. are covered under the Survey. Though servicing industries like motion picture production, personal services like laundry services, job dyeing, etc. are covered under the Survey but data are not tabulated, as these industries do not fall under the scope of industrial sector defined by the United Nations. Defence establishments, oil storage and distribution depots, restaurants, hotels, caf and computer services and the technical training institutes, etc. are excluded from the purview of the Survey.

- For growth accounting TFP estimates, I use Cobb-Douglas specification with income share of capital as 0.3

- When accounting with materials, in addition to above a share of 0.3 is used for material input and hence 0.4 as share on labor.

- User cost is used as price for capital services.

- I use the Data Envelopment Analysis technique for time-series rather than cross-sectional data. It would mean that how production envelopment (which should be in the last period) compares to previous periods' production technologies.

- If we use 0.6 as the weights for input (which in fact is the cost share), then estimates of TFP growth using Growth Accounting techniques are even lower than reported.

- For Organization type, Employee series is available for 1973-1997 and Workers is available from 1979. Workers series for earlier years is derived assuming a constant employees-to-worker ratio.

- TFP indexes are calculated using Net-Value added, but since input series are not available.

- Wages for earlier years are extrapolated same wage inflation as the first available value (i.e. 1979).

- For stochastic frontier, Net-Value-Added is used for Organization while Gross Output is used for Ownership due to data limitations.

- **Note about sector specific deflator**
  For beverages (155) and tobacco (160) same deflator were used. 171 - Cotton Yarn. 172 - Jute, Hemp & Mesta Textiles. 181 - Cotton cloth mills. 182 - Woolen textiles. 191 - Leather, Leather Products. 201 and 202 - Wood Products. 261 - Glass and Chinaware products. 269 - Cement, Slate and Graphite products. 281 and 289 - Metal Products. 291 - Non-electrical machinery & parts. 292 - Industrial Machinery. 312 - Industrial Electrical Machinery. 313 - Industrial Wires and Cables. 314 - Dry & Wet Battery and cell. 293 - Refrigerator. 300 - Type Writers. 321 - Radio & TV sets, computers. 331- Electrical Machinery. 332 - Other Manufacturing. 341 - Scooters. 342 - Car chassis. 351, 352, 353 and 359 - Transport Equipments. 361 - Wood Products. 369 - Other Manufacturing. 402 - Mineral oils. 526 and 603 - CPI.

  For Water Supply & Distribution (410) - Price index is calculated by using current and constant prices GDP for Water Supply from National Accounts Statistics.

- For missing years, prices are calculated by just extrapolating the series using last available values (using excel series function).

- When data is not available (e.g. 221 - Publishing , before 81), nearest related price series (e.g. Paper products) is used.

- Different indices (change of base) are combined using usual formula of multiplying the common year value. $P_{t+1}^{BaseSeries} = P_{t+1}^{NewSeries} * \frac{P_t^{OldSeries}}{P_t^{NewSeries}}$
  usually $P_t^{NewSeries} = 100$ for the year series starts.

- For Olley and Pakes, exit dummy is calculated as increase or decrease in the number of factories.

- For Decile calculations, 22 outliers were removed for capital per worker and capital (using the method of Hadi).

- $(TFPGDecile)^i = [TFPG^i - TFPG^{min}].div.[\frac{TFPG^{max} - TFPG^{min}}{10}]$

B TFP Growth by Industry Code

Table 15: Domar weights and Period-wise TFP Growth of industries

Code	Description	DomarWt.	74-03	Pre-90	Post-90
014	Agricultural	0.015	4.1	4.4	3.7
151	Meat	0.076	-0.4	-0.5	-0.3
152	Dairy	0.033	1.9	2.2	1.5
153	Grains	0.056	0.9	0.6	1.1
154	Other Food	0.242	0.5	1.3	-0.6
155	Beverages	0.048	0.9	1.6	-0.1
160	Tobacco	0.08	-0.5	-0.1	-0.9
171	Textiles	0.6	1.2	2.4	-0.3
172	Other textiles	0.022	1.6	0.9	2.4
173	Knitted Articles	0.016	-1.8	-1.1	-2.7
181	Wearing Apparel	0.049	1.9	5.1	-2.2
182	Fur	0.0003	6.9	4.9	9.5
191	Leather	0.016	0.9	-1.1	3.6
192	Footwear	0.022	1.1	1.2	1
201	Saw milling	0.005	0.7	1.5	-0.3
202	Wood Product	0.015	-0.1	0.9	-1.4
210	Paper product	0.102	0.9	1.6	-0.1
221	Publishing	0.054	0.5	0.4	0.5
222	Printing	0.027	-1.1	-0.7	-1.7
231	Coke Oven products	0.02	2.2	1.8	2.6
232	Refined Petroleum	0.176	2.4	4.5	-0.2
241	Basic Chemicals	0.358	1.9	1.3	2.8
242	Other chemicals	0.393	1.7	2.5	0.6
251	Rubber Products	0.084	1.8	1	2.8
252	Plastic Products	0.049	2	1.3	3.1
261	Glass Products	0.025	3.3	4.3	2
269	Non-metallic products	0.193	0.7	1.2	0
271	Basic Iron	0.477	1.4	0.2	2.9
272	Precious Metals	0.083	1.5	1.8	1.2
281	Structural metal	0.064	1.6	-0.1	3.9
289	Fabricated metal	0.064	1.8	0	4.2

Continued on Next Page...

Table 15 - continued

Code	Description	DomarWt.	74-03	Pre-90	Post-90
291	General Machinery	0.136	2.1	1.7	2.7
292	Special Machinery	0.174	2.1	2.5	1.5
293	Domestic Appliances	0.032	4.4	5	3.7
300	Office Machinery	0.028	4.1	4.1	4.1
311	Electric Motors	0.116	3.3	3.4	3.3
312	Electricity Distribution	0.026	2	4	-0.6
313	Insulated Wire	0.042	2.5	3.2	1.5
314	Primary batteries	0.02	2.5	3.6	1
319	Other Electrical	0.001	4.8	4.4	5.2
321	Electronic Valves	0.014	5.5	5.3	5.8
323	Television Radio	0.051	6.4	6.3	6.7
331	Medical Appliances	0.03	2.7	2.8	2.6
332	Optical Instruments	0.003	4.7	3.7	5.9
333	Watches	0.011	5.8	5.4	6.4
341	Motor Vehicles	0.182	3.4	1.9	5.4
342	Bodies for Trailers	0.005	-0.4	-1.1	0.5
351	Ships Boats	0.021	2.6	0.9	4.8
352	Tramway Locomotives	0.071	3	0.6	6.1
353	Aircraft Spacecraft	0.008	1.5	0.4	2.6
359	Transport Equipment	0.06	2.4	1	4.2
361	Furniture	0.014	0.4	0.8	0
369	Misc. Manufacturing	0.032	5.4	5	5.8
401	Production of Electricity	0.761	-0.2	0.3	0
402	Gas and Gaseous Fuels	0.008	2.8	-2.2	15.2
410	Purification of Water	0.01	10	8.8	13.2
526	Repair of goods	0.06	9.9	3.2	26.3
630	Supporting Transportation	0.006	2	3	0.2