An Analysis of Economic Growth in India

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Abstract

This dissertation is an empirical study of economic growth in India over the period of 1960-2004.

The objective of the first chapter is to provide robust and reproducible period-wise growth estimates for India. Detailed growth accounting shows that without accounting for human capital, total factor productivity (TFP) differences over time account for 48% to 69% of the output variation. If we include the role of education, TFP growth accounts for 35% to 70% of the total GDP growth between 1960 and 2004. Starting from a modest rate in the 1960s, productivity growth dipped and became negative in the 1970s. This productivity growth rate began accelerating during the 1980s and it grew at an average rate of around 3% in the 1990s.

Chapter 2 calculates a large set of productivity growth estimates using the Annual Survey of Industries data. The results show that even though the net-value-added for all registered manufacturing grew at around 4.4% per year, the average yearly TFP growth rate was only 2.2%. In the sub-period of 1991-1997, input growth jumped but TFP growth became negative. But after 1998, the trend is reversed and output grows because of positive and large TFP growth in spite of the moderating input growth. Production function estimates show that in gross output the share of materials is 0.6, much larger than the capital and the labor shares. "Public corporations" experienced significant TFP growth after the reforms.

The last chapter provides an explanation for the sluggish performance of Indian manufacturing before the reforms. The interaction of quantitative restriction policies and inflexible labor laws distorted the allocation of resources between intermediate inputs and labor inputs. Moreover, the combination of high inflation and the unavailability of credit exacerbated this factor distortion and lowered productivity growth further. Using panel data on Indian industries, this chapter finds underutilization of materials compared to labor until recently. The productivity growth is negatively related to labor growth and positively related to materials growth. Real wages and labor productivity are negatively related to materials inflation and this relationship breaks down after the capital market reforms in the 1990s.

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Chapter 1

Indian Economy - TFP or Factor Accumulation?

1.1 Introduction

In the recent years, the economics of growth has been one of the most fascinating research topics. There seems to be a general agreement among economists and policy makers that growth of output-per-worker in a country should be one of the most desirable objectives. The success of East Asian economies in the 1980s reinvigorated interest in this topic. However, these countries were relatively small and researchers wondered whether the same lessons would work elsewhere. The remarkable economic growth of India after the 1990s provides an indication that conventional policy prescriptions do work. That is the reason why Indian economic growth is often showcased as an accomplishment of good economic policies. The Indian economy struggled to grow in the 1960s and 1970s, supposedly due to government controls in all aspects of the economy. Then India slowly began opening up its economy for trade. In the early 1990s it adopted broad based market reforms, which culminated in the Indian economy growing at 7% to 9% per year.

A country of over a billion people that was struggling with a currency crisis in 1991 managed a complete turnaround just by following good economic advice. And what a turnaround it has been. This paper studies the economic growth of the Indian economy and this *surge* in growth rates. The results and insights from this paper should be interesting and useful to a wider audience, since it addresses one of the most important economic stories of our time.

How did India manage to achieve this? How did this growth happen? What triggered this shift in the growth pattern? A simple question, such as how much of the growth can be attributed to various factors, gets different answers. Even though most of the researchers agree on the methodologies, the results obtained from the resulting growth accounting exercise are frequently not similar. One of the main reasons for varying results is the fact that productivity growth and technology change cannot be easily measured. There is no perfect instrument to proxy for these unobservables. Thus, when using conventional growth accounting techniques, economists attempt, as best they can, to measure output and input growth; the difference between output and input growth (the residual) is then attributed to the combined effects of efficiency and technology changes. The task of developing robust input series was difficult in the case of India where availability of accurate data was a problem until recently.

This paper constructs a growth accounting dataset for the aggregate Indian economy using data from various sources for the years of 1960-2004. I use the national accounts data from the Reserve Bank of India website. It provides a link to the *Handbook of Statistics on Indian Economy*, which is the compilation of national accounts time series based on Central Statistics Organization (CSO) calculations. The dataset contains most of the series as outlined in United Nations SNA (1993) [62]. For employment data the paper uses Groningen Growth and Development Centre's total economy database [17]. It has estimated labor series for India from 1961 onwards using publications from Asian Development Bank. For human capital measures, Barro-Lee (2000) [9] international database on education attainment and CSO's data on education enrollment in India is used.

A reproducible series for physical capital stock in India is generated using the investment data from the national accounts. The paper also generates the human capital stock series using measures such as average years of schooling and primary/ secondary/ post-secondary enrollment and completion. The growth of input accumulation (of physical and human capital) is higher in the earlier periods, 1960s and 1970s, as compared to the later years. State-led industrialization and a focused national education policy made this possible. Ironically, these government initiatives occurred at a time when government regulations were continuously increasing and as a result the productivity and efficiency of the Indian economy trended down during this period. The period following 1991 shows exactly the opposite trend. Despite failing to accelerate physical capital or human capital accumulation, the Indian economy was able to produce much higher output due to increases in total factor productivity growth.

Another important aspect of the evolution of the Indian workforce is the difference in the growth of workers at various education levels. The growth in post-secondary education is remarkable (especially in the 1960s and 1970s), while in primary education the growth record of India is very poor. The paper combines these different human capital indicators to create quality-augmented labor input by using Mincer type regression coefficients for returns on schooling.

The aim of this paper is to do a detailed accounting and analyze the results with respect to the two of the most commonly used explanations for Indian economic growth. These two explanations for the growth surge after 1991 are the following ones:

- Increased capital accumulation due to reduced currency controls and capital market reforms or
- Increased stocks of human capital due to increases in Indias educated workforce and the pool of skilled workers

The paper finds that both explanations are not satisfactory. Much of the *difference in pre-reform and post-reform growth* is due to increases in total factor productivity growth. TFP growth is estimated to be *negative* in the 1970s, meaning that productivity was decreasing. In contrast, yearly TFP growth after the reforms averaged a very impressive 3%.

The paper also applies the variance decomposition techniques often used in cross-section data by treating each year as a separate observation of input, output and the production technology (including efficiency). Output growth is then decomposed into factor accumulation growth and productivity growth. The paper uses decomposition according to Klenow and Rodriguez (1997) [53]. Since there is still some debate about measuring human capital or the quality of labor input by using education indicators, the paper also performs one set of baseline calculations without augmenting the production function with human capital. With only unadjusted labor and capital as inputs, the results show that the productivity variations are responsible for 48% to 69% of output variations in the Indian economy between 1961 and 2004. These numbers may seem a bit high, but examined together with the results of the growth accounting exercise they make perfect sense. When input was growing output did not grow (period before 1990) and output grew faster when growth in input was very modest (period after 1990). That is why input growth alone cannot explain the growth in output of the Indian economy.

When labor input is adjusted using human capital, the unexplained or residuals' share drops to as low as 17% (when using the sum of primary, secondary and post-secondary educated workers as the measure of investment in human capital). The paper uses two sets of Mincer regression coefficients for India as calculated by Psacharopoulos and Patrinos (2002) [66] and Duraisamy (2000) [33]. The results show that input changes are responsible for only 55% and 62% of changes in the output respectively. The reason for this difference in residuals is the difference variance of the respective measures. The human capital per labor ratio used in the second approach grows from 1.1 to 1.6. This result is very close to one obtained by Lahiri and Yi (2006) [56]. The human capital per output ratio moves from 1.5 to 2.6 in the alternative decomposition. Following Caselli (2004) [21], the paper also checks the two success criteria to evaluate how much of the differences in output can be explained by input changes. The paper checks these decompositions and success criteria for levels and growth rates. Interestingly, the growth rate of the input is not positively correlated with the growth rate of output, as input and output accelerated in different time periods.

The second objective of this paper is to find out what happened to macroeconomic aggregates in the Indian economy between 1961 and 2004. There have been many studies on India's economic growth, but few of them provide reliable and reproducible growth accounting estimates. Lack of macroeconomic data has restricted researchers to concentrating on specific sectors only. Virmani (2004) [74] calculates the TFP trends for India, but his analysis uses the population between the ages of 15 to 64 as a measure of *potential workers* in his calculation. A clear analysis using estimates of human capital in India is very rare in the literature.

The paper attempts to come up with theoretically-sound estimates and analysis of period-wise macroeconomic growth in India. The results for trends in productivity growth are very clear. In 1960s, the average annual TFP growth was a modest 0.22%. It dipped to -1.16% in the 1970s before reaching a yearly average of 1.63% between 1981 and 1990. Productivity growth rate kept increasing, and averages 2.57%, 2.95% and 3.08% for the periods of 1991-1995, 1996-2000 and 2001-2004 respectively. The same period-wise trend is observed in the smoothed TFP growth series using HP filter. These trends are robust to the measure of human capital used and to the production function specification. India experienced accelerated input and output growth in different periods. The first two decades (1961-1980) were a period of high growth in factor accumulation, while output growth rate picked up after the 1980s. Hence the variance decomposition of *growth rates* consistently shows a negative relation.

These results confirm what economists have long suspected. The 1960s and 1970s were a period of controlled economy and what is often called license raj. It decreased the overall efficiency of the Indian economy and resulted in the productivity decline. Estimates show that productivity started growing once the first set of reforms was introduced in the 1980s, and its rate of growth increased as more reforms were adopted later. But what is different in the Indian context is the fact that the 1960s and 1970s were periods of high input growth as well. Unlike East Asian economies, the rapid (physical and human) capital accumulation could not result in significant output growth because of negative productivity growth. Stepwise economic reforms of later periods resulted in higher output per worker growth rates not because the reforms contributed to increased factor accumulation growth but because they helped in improving the total factor productivity growth in the Indian economy.

The paper also contributes to *inspiration vs. perspiration* debate by claiming that much of the difference in the growth performance of the Indian economy stems from efficiency gains rather than being driven by higher input accumulation rates. Skeptics might claim that a consistent growth of around 3% (as the paper finds) in production technology is impossible. But we have to remember that the estimated total factor productivity growth for an aggregate economy also measures many efficiency improvements. Given the extent of government bureaucracy in India, it should be no surprise that such large efficiency improvements were possible. Even though relying entirely on these total factor productivity gains for future output growth would be a huge mistake since the scope of efficiency improvements reduces as one becomes more efficient, the results in this paper clearly show that the recent surge in Indian economic growth is due to TFP growth rather than the conventional factor accumulation growth.

The growth in labor input has been very slow and averages only 1.7% per year after the reforms; this is worrisome given that the Indian workforce has been growing at a much faster pace throughout these years. Indian policy makers will have to address this issue if they want the growth to be more *inclusive*. Increasing the labor input without reducing the capital per worker (which is the main determinant of labor productivity) would require significant investments in both physical and human capital. With recent increases in tax revenues and encouraging trends in foreign direct investments, this task seems achievable.

In the following sections, the paper gives a brief history of the Indian economy and then shows the period-wise growth rate of macroeconomic aggregates using simple indexes. Growth accounting and period-wise decomposition exercises are performed, first only with physical capital and then with human capital. Then the results from productivity growth estimation using human capital augmented labor input by applying the Mincer regression coefficients for return to schooling in India are discussed. Each section shows tables and figures for the estimates and discusses them in regards to the insights into India's economic growth.

1.2 (Post-Independence) Chronology of the Indian Economy

In 1950 (the year India became a republic) the population of India was 360 million, the life expectancy at birth was 41 years and the literacy rate was less than 20%. It was mostly an agricultural and rural economy. The share of primary sector was 60% in output and over 75% in workers. Nehru, India's first prime minister, faced with the daunting task of managing the economic aspirations of such a populace picked the route of *Fabian Socialism*. *Planning Commission* was created to carry out various "Five-Year Plans". These plans had a set of policy objectives which were implemented using various projects and outlays. For instance, the aim of the first plan was to achieve self-sufficiency in food production, while another later plan had government-led industrialization as its objective. Economic policies in India just after the independence were motivated by *import substitution*, *business regulations* and *state intervention*.

During the 1960s, manufacturing and other industries started growing. But this industrialization was being driven by the government. The state had the benefit (at the time) of mobilizing the resources at a much larger scale, but it also had inefficiencies (e.g. price of capital was often too high). One interesting objective of the economic policies in 1960s and 1970s was to protect the low-skill *Cottage Industries*. This protectionism led to government control in almost all aspects of business during the 1970s. *License Raj* became the norm. Government undertook the *Nationalization Drive*. Banks, insurance companies, mines, petroleum distribution, manufacturing firms and many other services were nationalized. These government-owned corporations were referred to as *Public Sector Undertakings*. Entry into these sectors was either entirely prohibited or severely restricted.

On the political side, India faced three wars during these two decades (against China in 1962 and against Pakistan in 1965 and in 1971). A state of emergency was declared in 1975. Then, in 1977, *Janata Party*[1] won the majority in the parliament and formed the first non-Congress [2] government in India.

India faced a balance-of-payments crisis and had to get help from the IMF in 1980. After the assassination of Indira Gandhi in 1984, Rajiv Gandhi became the prime minister. His government introduced the first set of re-

[1] A political party. Many of its members were arrested during the emergency rule.

[2] Congress is a political party in India. A member of Nehru family has been its leader for most of the time.

forms in mid-1980s. These reforms were aimed at liberalizing the export-import restrictions and industrial licensing regime. Government restrictions started to loosen. The late 1980s also saw the emergence of coalition government in India, with two prime ministers in as many years. The seventh five year plan (1985-1989) achieved the goal of 5% yearly growth, but it increased the fiscal deficit.

In 1991, India faced a *currency crisis* and foreign-exchange reserves dropped to only $1 billion. Prime Minister Narasimha Rao, along with Manmohan Singh, began the market and structural reform process. This included opening of the capital markets, abolishing the old industrial policy and removing many of the restrictions in various sectors of the economy. India joined the WTO in 1995. After winning the majority in 1999, the BJP government expanded the liberalization and decentralization initiatives. In late 1990s and early 2000s, the service sector started to grow rapidly due to the huge demand for *outsourcing* from western countries.

This has been a real roller-coaster ride. On the political front, India has moved from the same party winning the majority consistently to the coalition government becoming the usual phenomena. With regards to economic policies, India has experienced the movement from centralized state-controlled economy based on the Soviet model to an open, market oriented, capitalist economy. Fortunately, this transformation has been very positive for the Indian economy. It has become the 4th largest economy on the PPP basis. [3] The life expectancy at birth is now 68 years, the service sector accounts for more than half of the output, and the population growth rate has peaked.

The changes in economic policies and the presence of many political shocks make the task of analyzing the Indian economic growth interesting and challenging. The recent debate in literature about what *triggered* this growth is an indication of this challenge. The 1980s vs. 1990s discussion arises partly because the economic policies have not been coherent and have not been consistent with the earlier ones until very recently. These shocks in policies and initiatives reflect in data, and the growth rates (of output and productivity) fluctuate a lot between periods. That is why a time-series analysis of comparing period-wise growth rates depends hugely on the choice of sub-periods. One way to avoid this problem is to study the *trends* in growth rates over time rather than comparing just the estimated averages. The paper finds that there are trends in productivity growth that are robust

[3] India is ranked 4th on GDP PPP-comparison on each of the World Bank, IMF and CIA fact-book rankings.

to the choice of growth accounting technique used, such as production function with or without the human capital, variance decomposition vs. Solow type accounting, different measures of the human capital, and capital-labor vs. capital-output forms of the Cobb-Douglas production function.

1.3 Macroeconomic Indexes: 1961-2004

The time period between 1961 and 2004 has been very interesting for the Indian economy. From being categorized with sub-Saharan African economies, India has gone on to become a success story of the market reforms and is often used as an example for making a case for the democratic institutions. India has seen the metamorphosis of its economy during this period. Panagariya (2004) [65] and Rodrik and Subramanian (2004) [71] highlight this transformation and attribute it to the success of the economic reforms. To find out what was happening during these years, the paper collects national accounts data and constructs the input-output series needed to perform the growth accounting. The dataset is created using various sources. The list of data sources is included in Appendix A. Many of the series start from 1950, but the labor force estimates are available only from 1961 onwards. Since labor is crucial for both per-worker productivity and total factor productivity calculations, the paper reports the results from 1961 to 2004.

These economic time series are converted to simple *indexes* which make the comparison across sub-periods and comparison between different economic variables very easy and intuitive.

For each time series, the index is obtained by dividing the value for current period by the base period value. This way each series starts with a base period value of 1.

$$Y_t^{index} = \frac{Y_t}{Y_{1961}}$$

Then to calculate the average [4] of the annual growth rates between periods t_1 and t_2, I use -

$$g^{t_2,t_1} = Y^{t_2,t_1}_{GrowthRate} = \frac{\sum_{t=t_1}^{t_2} (\frac{Y_{t+1}}{Y_t} - 1)}{[t_2 - t_1]}$$

Choosing the sub-periods is a more controversial issue. Ideally, we should select the sub-periods based on the possibility of structural breaks. But it becomes an issue for India since there have been too many changes both

[4] The geometric average could have been used instead, but since the main objective of the paper is to find whether the factor accumulation growth or the productivity growth was responsible for output growth in India, a consistent use of arithmetic mean should be as accurate. The only difference is that the numbers represent the average of annual growth rates rather than compound average annual growth rate.

politically and economically. Studies like Bosworth, Collins and Virmani (2006) [18] do not provide much help as choosing any set of sub-periods is problematic. Period-wise growth averages change significantly if one moves the boundary of the sub-periods (e.g. from 1980-1990 to 1981-1991). In fact this is one of the main reasons that researchers could not agree on whether productivity growth was higher in the 1980s or in 1990s. This paper tries to avoid this issue by estimating the trends in these growth rates. All sets of growth estimates are plotted and the trends in those are studied. These trends present a very unambiguous time-line of growth in the Indian economy. The paper also applies growth decomposition techniques, which are useful in finding where the output (and output-per-worker) growth is coming from. [5]

The paper reports the growth rate results by decades, with the 1990s divided into two sub-periods. In fact, many of the structural changes in the Indian economy coincide with the boundaries of these sub-periods (which are 1961-1970, 1971-1980, 1981-1990, 1991-1995, 1996-2000 and 2001-2004). The paper discusses the estimates for these sub-periods along with the longer term overall growth trends.

1.3.1 Output - Quantities and (Implicit) Prices

Table 1.1 summarizes the growth in macroeconomic quantities and prices for each of the sub-periods. It also shows the corresponding growth in various components of the GDP (C,I,G,X,M). These indexes are plotted in Figures 1.1 and 1.2.

Output growth slows down in the 1970s to an annual average of 3%. This drop is just 1% compared to the average during 1960s, but this statistic does not tell the whole story. The slowdown in labor productivity (output-per-worker) is very significant in this second sub-period (1971-1980). The average annual output-per-worker growth rate over these 10 years is ZERO. Hence, the performance of the Indian economy during the 1970s was worse than just a slight drop in the GDP growth. Labor productivity is a better indicator of economic performance since it corresponds more closely to the most common welfare measure of real GDP per capita. It seems that the

[5] There is still a possibility of dividing the sample into sub-samples for the growth decomposition as well, but it comes at the huge cost of losing data points and hence this paper does not do that. Another important reason for not doing decomposition using sub-samples is that the whole transition of the Indian economy will not be reflected in any of the sub-samples. Thus the decomposition results (e.g. TFP growth accounted for x% of output growth in the 1980s) will not be very meaningful.

1970s were a lost decade for India in terms of productivity growth. Casual explanations, such as India fought a war and faced an emergency rule during this period and thus experienced lower GDP growth, cannot explain the stagnation in productivity. As this paper shows in later sections using detailed growth accounting, the average total factor productivity growth was in fact negative between 1971 and 1980. This result points towards increased economic inefficiencies (in resource allocations), probably due to the drive towards nationalization and other government regulations introduced in various industries.

Growth estimates for later sub-periods show the opposite trend. GDP growth rates jumped and averaged at 5.6% in the 1980s and then increased to 6.4% per year between 2001 and 2004. Interestingly, while the output started growing at a much faster rate, the growth in employment slowed down (average growth is just 1.9% in the last sub-period compared to 3.2% in 1970s). This means that the growth in output-per-worker increased. Notice that this jump in the average output-per-worker growth rate from 0 to 2.8% to 4% represents the *acceleration* in the productivity of the Indian economy since 1981.

This trend of single factor productivity (output-per-worker) growth rates dipping in 1970s and then picking up again in 1980s is also observed in various TFP estimation exercises in later sections.

The indexes for the GDP components (in real terms) and their growth rates are also interesting. Private consumption has grown only 5.1 times between 1961 and 2004 compared to the 13 times increase in government consumption. The investment became 15.2 times its starting value. Exports and Imports grew 15 times and 16.3 times in just 34 years, between 1970 and 2004. The growth rate of government consumption has been higher than the growth rate of private consumption growth for almost all the sub-periods except for the last. Investment growth averages around 13% per year between 2001 and 2004.

Growth rates of GDP component prices (i.e. inflation) have averaged between 7% and 10%. This is very high especially when compared to moderate inflation during the 1980s onwards that most of the developed countries experienced. Import prices increased at a much faster pace than the prices of exported items. In the years following the capital market reforms (last 2 sub-periods), the growth in prices seemed to have moderated. Movements of the relative price of capital goods ($\frac{P_I}{P_C}$) is plotted in Figure 1.4. It is less than 1 in the 1960s, but starts to increase in 1970s and reaches the peak during the currency crisis of 1991.

In Figure 1.1, we can see that output and labor were growing at a similar rate (the flat portion in Panel A) until 1970s, but then output just skyrockets. It grows at a considerably higher average annual rate (6%-7%) compared to labor (1%-3%) as shown in Panel B. This results in output per worker growing at a faster rate (3% - 4%) and the output per work curve becoming steeper. These calculations (and trends) of output per worker are similar to the ones obtained using purchasing power parity calculations (e.g. Penn-World Tables). The difference in values is due to the labor series.

Figure 1.2 illustrates that all the output quantities (C,G,I) clearly show a **flat part** representing a slow growth period between 1960-1980 and a **steep part** for the period after 1981 when these series grew at a much faster rate. In Panel A, consumption seems to show this flat portion until mid-90s, and even after that the growth rate increase is not as prominent as for other quantities. For export and import the pattern is similar, but the flat period is from 1970 to 1990 and after that higher growth rates result in steeper plots.

1.3.2 Input - Physical Capital and Investments

Physical capital is one of the most important factors in economic growth. It includes the durable inputs, such as machinery and equipments, which make workers more productive and as a result output per worker increases. Capital stock also accounts for things like infrastructure and buildings which affect productivity indirectly. Sometimes new capital comes with *embodied technical change*, where the new equipment also allows the firm to use a new (and improved) production process, generating higher output. But creating the capital stock series is not a straight forward task. The problem is that older capital loses its value and is being constantly replaced (at least at the aggregate level) with investment in new capital goods. This paper uses "*Perpetual Inventory Method*" to construct the physical capital series for the Indian economy. The quantity of capital stock is created by assuming an initial stock of capital and then for each period adding the new investment net of the depreciation to the existing capital stock.

National Accounts division of CSO provides the data series on investments and savings. These include gross and net domestic capital formation, gross fixed capital formation and gross domestic savings. In fact, the neo-classical growth model suggests that savings rates are an important determinant of how quickly the country's income level will converge towards its long-term steady state. Higher savings rate (and hence higher stock of capital) implies a faster growth according to these models. Singapore is a nice example of such a case where savings rate was around 40% of the GDP, registering significant economic growth. The paper finds that India did not have these kinds of savings rates. As Figure 1.3 shows, the gross domestic savings to GDP ratio for India was 0.12 in 1961. It has grown significantly since then and the savings rate is 28% in 2003.

The paper calculates the growth rates of these savings and investments series. Period-wise growth averages are summarized in Table 1.2. The growth rate in capital formation and domestic savings was impressive between 1981 and 1990, but dropped sharply in the 1990s because of balance-of-payment crisis. In the first four years of 21st century, the growth rate in capital formation measures has averaged between 11% and 20%.

Figure 1.3 also shows growth in different measures of physical capital formation. Domestic capital formation to GDP ratio has increased by approximately 100% (both Gross and Net) over the period of 44 years (panel A). Gross Domestic Savings grew 16 times, at a flat rate until the mid-1980s and more rapidly after that. The savings rate (ratio of GDS to GDP) has increased 2.5 times during the same period (panel C). This can also help explain the growth pattern of the GDP components, with consumption growing a lot slower than the investment.

The significant increase in growth rates of savings in 2000s can be attributed to the increased trust in financial market institutions. In 2004, the savings rate and the gross domestic capital formation to GDP ratio are around 30%.

Even though savings and investment (capital formation series) are indicators for capital input, these are flow variables. The actual input to the production process is the capital stock which is derived by accumulating the (net) investments over all previous time periods. The growth rate of capital stock and trends in those growth rates need not be similar to the trends in investment. In fact this is exactly what happens in the case of the Indian economy. The paper creates the physical capital stock series using these investment measures. The results are discussed in the next section.

1.3.3 Input - Education and Human Capital Indicators

One of the most commonly used explanations for Indian economic growth is that a highly educated workforce and the abundance of skilled labor in India made it possible. This explanation is based on the simple logic that an educated worker can produce a higher amount of output with the same amount of input because he can perform better, follow instructions better and use the machines (capital input) more efficiently. As pioneered by Mankiw, Romer and Weil (1992) [59], one can augment the actual production function to reflect this concept of *Human Capital.* The idea is that if we take care of improvements in the quality of the labor force, we can explain the output growth more accurately. This paper's result, that the growth in the education level of workforce cannot explain much of the growth in the output for the Indian economy, should not be viewed as *failure of human capital to be relevant in accounting.* In fact, the opposite is true. After accounting for human capital changes, the contrast in pre-1980s and post-1980s efficiencies (as measured by the residual TFP growth rates) of the Indian economy becomes a lot more emphatic.

There are disagreements about the use of this human capital concept. Many labor economists question the assumption that human capital is tangible. This objection has merits because as empirical results show, productivity of workers and their wages are functions of many unmeasurable characteristics. The problem becomes especially relevant when these unmeasurables are not correlated with the education level or other commonly used measures of the human capital. In such a scenario, creating a series for human capital stock and using it in growth accounting will corrupt the estimates.

Since the objective of this paper is to find out whether the factor accumulation and its growth can explain the changes in output-per-worker growth in India, both sets of results are presented; with and without human capital. Even though the objections raised by critics of human capital are valid, we need to include some aggregate measure of workers' skills. This is crucial because the service sector's share in most economies is growing and skilled workers are the most important input to the services production process. If one believes that the education measure being used is not indicative of the general level of skill-set in the economy, he or she should try to improve that measure rather than just drop it from the accounting equation. One such nice modification is the *return to education* concept used in this paper.

The paper uses the data on education attainment in India. One of the most important (or at least most used) measures of human capital is workers' education. The paper creates the time series on enrollment and completion rates for various education levels (primary, secondary, post-secondary, university) and average years of schooling. The quality of education itself can change over time. Measures such as number of teachers per 1000 students or students in each class/ school can be used as indicative of the quality of education in absence of more direct measures such as standardized test scores of graduating classes.

A few of the series in the education data are based on household surveys, which were done at 5 year or 10 year intervals. The values for intermediate years are extrapolated in such cases. Since we are using these series in growth accounting, it might make the point estimates inaccurate. That is why the paper studies the longer term growth trends as well which are more likely to be correct.

As previously, the series on different education measures are converted into the corresponding indexes by equating the value in 1961 to 1 for each of them. Calculated growth rate averages in the education levels and other human capital measures for different sub-periods are summarized in Table 1.3. These indexes and growth rates are interesting as they show period-wise and overall trends that are different from the output growth trends.

The percentage of the population over 15 years of age that have attained some primary education grew at an average rate of 1% per year compared to the average annual growth rate of 5.4% and 6.7% for secondary and post-secondary. Two points are important to remember. First is that during these years the population of India increased by 230%. The second point is regarding the difference in the levels (the actual values) for these different measures. Even though the increase in percentage of those who have enrolled at post-secondary level became 14.73 times its starting value, it is still just 4.42% of the total population over 15. This shows the importance of starting levels in the growth exercise and hence the discussion should consider both the levels and the growth rates.

Unlike the growth trends in output and investment, the growth rates in human capital measures seem higher in the 1960s and the 1970s. This reflects the fact that early policy makers put a lot of serious effort into education. Earlier five-year plans had many projects/ initiatives and setup many commissions with the aim of developing a scientifically inclined manpower. In 1968, a comprehensive *National Policy on Education* was adopted.

Since the human capital indicators were growing fast in the 1970s and consequently the labor-force quality was constantly *improving*, the labor productivity should have grown at a faster rate. But the lower output per worker growth (growth rate average of zero) in the 1970s compared to the other sub-periods implies that the total factor productivity must have been going down during the 1970s. Various accounting exercises in the later sections of this paper confirm it.

Another interesting part of the 1970s is the slowdown in the primary attainment percentage. The huge negative average of -6.8% is very surprising because the yearly population growth rate between 1971 and 1981 was just 2.2%. Since the number of people who have already attended primary education cannot decrease, the reason has to do with India's population pyramid at the time. India had a large number of people becoming 15 years of age every year during that decade. Population projections show that around 30% of population was between the ages of 5 years and 14 years in 1971. Indian government did not take this into account and focused their attention on higher education (universities, technical colleges and engineering institutes) instead.

The movement of the education measures is plotted in Figure 1.5. The flat periods and steep periods are not as prominent as for the output and the investment series. Panel A shows that for the post-secondary enrollment percentage, 1960-1975 was a period of very high growth and the growth slowed after that as indicated by the flatter graph. The movement of indexes for number of students by different education levels (Panel C) highlights the difference in growth paths of university and post-secondary education and of primary education. The same trend holds for education quality indicators such as number of education institutes by education levels. The growth in the number of primary schools is tiny when compared to the growth in number of colleges and universities.

1.3.4 Labor, Unorganized Sector and Self-Employment

Estimating the number of workers should be a relatively straightforward task, but not for India. Apart from the usual problem of having to extrapolate the intermediate years' values, a more serious issue is that of the informal sector. Ministry of Labor in India defines the informal sector 'as consisting of units engaged in the production of goods and services with the primary objectives of generating employment and incomes to the persons concerned'. This sounds like the usual definition of household production or what is often referred to as *self-employed*. The statistical agencies in most developed countries report this self-employed series (estimated from the tax data). But for India this series needs to be generated. According to a 1999-2000 survey, only 28 million workers are employed in the organized sector out of the total workforce of 397 million. This means that more than 90% of the workers are in the unorganized sector [6].

The paper uses the labor series from the *Total Economy Database*. This employment (or number of workers) series is calculated using the data from decennial population censuses of 1960, 1965, 1970, 1975, 1980 and 1985. Movements for in-between years are interpolated with the average growth rate over 5 years. Data for 1987-2007 is derived from the principal status

[6] The unorganized sector refers to those enterprises whose activities or collection of data is not regulated under any legal provision or do not maintain any regular accounts. The informal sector is a sub-set of the unorganized sector.

definition of workforce from the household survey, National Sample and Survey Organization (NSSO), Government of India, to calculate the work force participation rate. These are then used in conjunction with the Central Statistical Organization (CSO) estimates of population based on the census to obtain the total employment.

Using the labor series derived from the survey data for aggregate growth accounting is acceptable. As mentioned in Table 1.1, the labor growth rates have been relatively low. This, combined with the fact that the labor market in India is very inflexible and does not have major sudden changes, means that the extrapolated numbers between the survey years will be very close to the actual ones. The longer term trends shown in this paper will be correct even if the point estimates might contain some mistakes due to this extrapolation.

1.3.5 Land Input

The agriculture sector accounted for more than half of Indian GDP in 1961. Since the land is an important input to agriculture, it should be included in the production function. But there is the issue of its relevance as an input for other sectors and variation of its overall importance due to the decreasing output share of agriculture. That is why most of the studies do not use land as an input in aggregate production. Luckily for India, such a choice does not come at a cost. India already was an extensively agricultural economy in 1961. The net sown area (land input) has not increased much since then. It has remained at around 140 million hectares. The net irrigated area has almost tripled since 1960s (from 27 million hectares to 79 million hectares). But it should be accounted for as capital input, i.e. investment in canals, tube-wells etc. and not as land input.

1.4 Baseline TFP Estimates

What explains the differences in output per worker and its growth rates across time as seen in Table 1.1? The growth in capital intensity might be responsible for these differences or the gains in the efficiency of the Indian economy may be causing output per worker to change over time. Literature explaining these differences across countries presents equally convincing papers in both categories. There is the *neo-classical* view claiming that output levels and growth rates are different because of the differences in capital. The other claim, often grouped as *endogenous progress*, is that differences in output levels and growth rates are due to technology differences. Another objective of this section is to find the productivity growth trends for the Indian Economy during the study period. Was total factor productivity growth in the 1960s lower or higher than the growth in 1970s and what happened to it after the capital market reforms of the 1990s?

In fact, both the factor accumulation changes and the production technology changes are responsible for changes in output levels of a country (and its growth rates). The debate now is about which one of these two is more important. This paper shows that for India, it is the jump in productivity growth that is responsible for the acceleration in output experienced after the 1990s.

To perform this analysis the paper constructs the capital stock series for India. This section does not consider the human capital because using it explicitly in the production function still raises objections from the critics. The paper calculates the baseline TFP [7] growth rates by using the physical capital only and includes the human capital measures in later sections.

1.4.1 Capital Stock Growth

The capital input defines durable assets such as machines and equipments, buildings and structures etc. Creating a series representing the quantities of these assets is tricky. The paper uses the *Perpetual Inventory Method*, recommended by OECD and System of National Accounts. It constructs estimates of capital stock and consumption of fixed capital from time series of gross fixed capital formation. It allows an estimate to be made of the stock of fixed assets in existence and in the hands of producers which is generally based on estimating how many of the fixed assets installed as a result of gross fixed capital formation undertaken in previous years have survived to the current period.

As mentioned earlier, the data is available in volume (current value) series and quantity (deflated by price of capital good) series. The paper constructs the capital stock series by assuming a geometric depreciation model.

$$K_t = (1 - \delta) * K_{t-1} + I_t \tag{1.1}$$

[7] These baseline TFP growth rate estimates include the *intangible gains* due to the increased worker education, just like they include the gains from workers' increased experience with the machines. In later sections, the paper tries to explain some of these intangible gains by accounting for the increased education attainment of the workforce.

The paper uses investment quantity series. A baseline capital series is constructed by assuming K_0 as 1.5 times the GDP and δ equal to 6%. These values are chosen because they are quite standard in the literature. The paper also generates many other possible capital series and re-estimates the growth rates to check their sensitivities with respect to these assumed values. The baseline series is estimated using gross domestic capital formation as measure of investment and a constant depreciation rate.[8] The other capital stock series are estimated using net domestic capital formation as investment net of depreciation and using gross fixed capital formation plus changes in the inventories as the measure of investment. The results reported in the paper are based on the baseline capital stock series unless specified.

The *accumulation* of each year's investment into the capital stock has some interesting properties. Since it is a stock variable, the growth rates of K stock will be a lot lower (for the same amount of I) in the later periods because the *base* keeps increasing. Put another way, it is easier (requires less investment) to have faster K growth rates when the economy is small. This becomes obvious by rewriting the capital accumulation Equation 1.1 as -

$$\frac{\Delta K}{K} = \frac{I_t}{K_{t-1}} - \delta \tag{1.2}$$

In the economic growth models, capital-output and capital-per-worker are two very important ratios. Researchers on either side of the debate talk about these ratios. Neo-classical models suggest a steady state value of capital-output ratio (depending on savings rate and population growth rate), while in endogenous growth models the growth happens because of the increased investment (and hence increased capital-per-worker) by innovators seeking to get monopoly profits for a while.

Figure 1.8 plots the movements of estimated $(\frac{K}{Y})$ & $(\frac{K}{L})$ ratios (Panel C) and their period-wise growth rate averages (Panel D). The growth rates of both these ratios show similar period-wise trends. These ratios grew at an annual average growth rate of 6% and 9% in starting periods, but the growth rate stabilized in later periods to 0% and 4% respectively. The figure also plots the movement of $(\frac{K}{Y})$ under different alternative K_0 and alternative δ in Panel A and Panel B. The movement is similar to the baseline case and since the study period is 44 years, the final ratios are quite close even

[8]Even though the capital stock values using the official depreciation estimates (i.e. consumption of fixed capital series) are not far from the ones obtained using the geometric depreciation model with perpetual inventory method, the fluctuations in the growth rates are higher in the series obtained using the official depreciation.

for the very different K_0 (3 times more). The capital-output ratio seems to have stabilized. It grows for the period of 1961-1980 and then reaches its new value. The average growth rate is almost 0 during the 1980s, 1990s and 2001-2004. Growth rates of capital per worker ratio are also interesting. The growth rate has been stable at 4% since the 1990s. $\frac{K}{L}$ ratio seems to have reached the steady state in growth rather than level (i.e. constant growth rate).

1.4.2 Accounting for Differences Across Time

Well-established growth accounting techniques can be used to attribute the growth in output to these two sources: factor accumulation and productivity improvements. The two effects can be disentangled by using the aggregate production function of the economy, and making some assumptions about the shape of the production function itself or about the markets for the factors. But most of the previous studies have focused on explaining the cross-country productivity differences rather than the differences across time.

The paper applies standard growth accounting using the following two production models:

$$Y_t = A_t * f(K_t, L_t) \tag{1.3}$$

$$Y_t = f(K_t, A_t * L_t) \tag{1.4}$$

These production functions [9] differ in their treatment of technological change parameter A_t. In Equation 1.3, it is *Hicks-neutral* TFP parameter, while in Equation 1.4 it represents *labor augmenting technological change* or Harrod-neutral TFP.

For a Cobb-Douglas functional form, the above two production functions can be rewritten in terms of output per worker.

$$\frac{Y_t}{L_t} = A_t.(\frac{K_t}{L_t})^{\alpha} \tag{1.5}$$

$$\frac{Y_t}{L_t} = A_t.(\frac{K_t}{Y_t})^{\frac{\alpha}{1-\alpha}} \tag{1.6}$$

[9] The implicit assumption here is that the aggregate production function for the Indian economy remains the same. Factor shares in individual sectors might change. In this setup, such gains show up in TFP numbers.

Equation 1.5 shows output per worker as a function of capital per worker or *capital intensity* and total factor productivity. Equation 1.6 specifies output per worker as a function of capital-output ratio and labor-augmenting total factor productivity. These two As are related and the paper calculates both of them because some researchers might prefer one specification over another.

These two equations also hold in *log-difference* form. Hence the growth in output-per-worker is sum of the growth in capital-per-worker/ capital-output (weighted by a constant which depend on factor shares) and the growth in total factor productivity. We can apply techniques like variance decomposition analysis which are often used in accounting for cross-country output per worker differences. The paper develops a time-series counterpart of this approach by treating each of the individual years as a separate observation.

Representing the production function in the form of Equation 1.7, we can calculate how much of the variance in output Y is due to the variance in input X.

$$Y_t = A_t * X_t \equiv logY_t = logA_t + logX_t \tag{1.7}$$

Notice that X_t is the combined input, so for the Cobb-Douglas case it would be ($K_t^{\alpha} * L_t^{1-\alpha}$).

Klenow and Rodriguez (1997) [53] suggest that Equation 1.7 implies the following decomposition -

$var[lnY_t] = cov[lnY_t, lnY_t] = cov[lnY_t, lnX_t] + cov[lnY, lnA]$

Since Equation 1.7 also holds in the first difference form, we get

$$\Delta logY_{t,t+1} = \Delta logA_{t,t+1} + \Delta logX_{t,t+1} \tag{1.8}$$

A much more general form of the above equation can be obtained by calculating the differences for each time-period pair:

$$\Delta logY_{s,t} = \Delta logA_{s,t} + \Delta logX_{s,t} \tag{1.9}$$

The paper performs the following sets of variance decomposition exercises. The first one uses the levels of output and inputs, while the second one uses the growth rates of output and inputs.

$$KR_{level} = \frac{cov.[log(Y_t), log(X_t)]}{var(log(Y_t))} \tag{1.10}$$

$$KR_{\Delta} = \frac{cov.[\Delta log(Y_t), \Delta log(X_t)]}{var(\Delta log(Y_t))} \tag{1.11}$$

The paper also uses another decomposition technique which measures the success of the input variations in explaining the observed variations in the output. This method is attributed to Caselli (2004) [21]. The following two ratios are calculated for the Indian economy.

$$Success^1_{level} = \frac{var(log(X_t))}{var(log(Y_t))} \tag{1.12}$$

$$Success^2_{level} = \frac{[X_t^{90\%}/X_t^{10\%}]}{[Y_t^{90\%}/Y_t^{10\%}]} \tag{1.13}$$

Equation 1.12 measures the explanatory power of the input variance. This sucess criteria ratio will be 1, if there are no TFP differences between various time periods and variations in output are only due to the changes in inputs. Equation 1.13 takes care of the problem that estimated variances may be corrupted by the presence of the outliers. This second success criteria concentrates only on variations within 10th and 90th percentiles.

The paper extends this concept and defines the analogous success criteria for the growth rates.

$$Success^1_{\Delta} = \frac{var(\Delta log(X_t))}{var(\Delta log(Y_t))} \tag{1.14}$$

$$Success^2_{\Delta} = \frac{[(log(X_t))^{90\%} - (log(X_t))^{10\%}]}{[(log(Y_t))^{90\%} - (log(Y_t))^{10\%}]} \tag{1.15}$$

These techniques have not been used much in the time series context. The issue of stationarity is one of the problems when applying these decomposition methods to a time series data. Using the variance ratios as parameters in a growth prediction model will be incorrect. But since the objective of the paper is to explain the difference in output (and output growth) of some finite *observations*, we can treat each of them as a separate observation just as we would treat the observations for different countries. The paper applies the variance decomposition methods to the difference series (i.e. growth rates of inputs and outputs) as well. The problem of non-stationarity should not affect the growth rates series. Another thing to keep in mind is that the results from variance decomposition for a single country cannot be used for analyzing the structural relationship. This is because output growth is also affected by business cycle fluctuations. If the data sample is extended back to 1950 or forward to 2009, the variance decomposition results will change. That is why the results of variance decomposition methods applied to the timeseries data should be reported in such form as 'between 1961 and 2004, input changes accounted for x% of output changes in India'. The paper discusses these variance decomposition results together with the TFP growth estimates and longer term *trends* in TFP growth.

1.4.3 TFP Growth and Variance Decomposition Results

Using the data as outlined in above sections, the paper calculates the implied total factor productivity. In this benchmark case, the paper uses sum of gross fixed capital formation and change in inventory/ stock as measure of investment for generating the capital series. The factor share for capital is used as 0.3, which is the standard in the literature. Gollin (2002) [43] finds that for India the employee compensation to output ratio was 0.69 in 1980, implying a capital share of 0.3. Later, the paper checks how the results change with different assumptions about capital share (α), initial stock of capital (K_0) and the measure of investment (I). The long term trends in these estimated TFP growth rates, which fluctuate a lot, are studied using HP filter smoothing. Non-linear smoothing with various settings is also tried, but the smoothed series does not have the same average as the original series. Hence, only the results from HP filter smoothing are used in the paper.

Period-wise growth rate averages are shown in Table 1.4 and the movements of input, output and TFP growth rates (smoothed) are plotted in Figure 1.6.

Between 1960 and 2004, the total factor productivity grew at an average annual rate of 1.05% while the rate of labor productivity growth using the alternative specification was 1.5% during the same period. The productivity growth was sluggish in the 60s, but in the 70s the average growth in productivity was negative. This means that productivity of economy and labor force **decreased** during this decade. The productivity growth rate has been increasing since the 1980s. This hold for both the specifications and the trend remains the same even after using different kinds of smoothing.

Figure 1.6 shows the movement in productivity for the benchmark case ($\alpha = 0.3$; $K_0 = 1.5 * GDP[0]$; $I = GFCF + \Delta Stk.$). Panel C explains the growth phenomena of the Indian economy for the period of 1960-2004. During 1960s and 1970s, the growth in factor accumulation exceeds the output growth rate, making these the periods of negative productivity growth. The growth rate of output started increasing after the 1980s. Productivity growth also accelerated at the same time. Between early 1980s and mid-1990s, factor accumulation growth rate went down and has been stable since.

These calculations imply that the impressive performance of the Indian economy (i.e. high output growth rate) is mostly due to the increased productivity growth and that the factor accumulation growth has only a modest contribution. This validates the notion that efficiency improvements are responsible for recent increase in the growth rate of the Indian economy.

Sensitivity Analysis:
The calculated values of A and therefore its growth rates are sensitive to values of α and K_0 and the measure used in generating the capital stock series. The paper checks how the estimates and trends compare for $\alpha = 0.3$; $\alpha = 0.25$; $\alpha = 0.4$ and $K_0 = 1.5 * GDP[0]$; $K_0 = 1.5 * GDP[0]$; $K_0 = GDP[0]$; $K_0 = 2 * GDP[0]$ and if capital is calculated using $GDCF$ or $NDCF$ or $GFCF + \Delta Stk.$. The paper also calculates the TFP growth rate for capital depreciation rate $\delta = 0$; $\delta = 2\%$; $\delta = 6\%$.

Figure 1.7 shows the TFP estimates for each of this set of variations. For income share changes (Panel A) the estimated values of total factor productivity growth rate decrease with an increase in α. The difference in calculated growth rate is around 1% between $\alpha = 0.25$ and $\alpha = 0.4$. Period-wise trends remain the same for all kinds of variations in the parameters and measures.

For different initial capital stocks, different depreciation rates and different investment measures; the calculated TFP growth estimates differ only for first few periods and then they converge. Again the trends in growth rates are same as the benchmark case.

Variance Decomposition:
The paper uses the calculated capital stock series to address the question of whether factor accumulation or productivity is more responsible for the differences in output per worker.

The results are shown in Table 1.5. Total factor productivity changes explain 48% and using alternative specification, labor productivity is responsible for 69% of output per worker changes between 1961 and 2004 in the Indian economy. Both success criteria seem to imply that a considerable percentage of changes cannot be explained by changes in input (between 30% to 69% depending on the specification and the criteria).

KR decomposition does not give intuitive results for growth rates decomposition. One explanation is the business cycle movements. Success criteria

S2 shows reasonable values for growth rates.

1.5 Accounting with Human Capital

Human capital is one of the most useful yet controversial concepts in economics. It measures the stock of knowledge and skills of the workforce and represents the quality of workers involved in the production process. The idea is that education and work-experience improves the performance of a worker. Hence, everything else being equal, an economy with more educated and more experienced workforce will produce more output.

Even though everyone agrees on this basic premise, there is no consensus on how to use this concept in growth accounting framework, i.e. which measures to use, how to create the human capital stock series, how it should enter into the production function, and so on. In the case of the Indian economy, education (at least higher education and in terms of the number of students) has always been one of its strengths. The results of the growth accounting exercise in the previous section show that physical capital accumulation cannot explain the changes in output growth and most of the increase in growth after 1991 is coming from total factor productivity growth; i.e. unaccounted for. Can it be the case that this TFP growth represents the growth in skills and education levels of Indian workforce? This section uses different education indicators to construct a series for human capital and then include that into the production function. The results remain qualitatively unchanged.

The paper augments the production function by adding human capital as one of the inputs. The Cobb-Douglas specification with labor-augmenting TFP parameter A is used. The Hicks-neutral A can be obtained from it very easily.

$$Y_t = K_t^{\alpha} H_t^{\beta} (A_t L_t)^{1-\alpha-\beta} \equiv \frac{Y_t}{L_t} = A_t.(\frac{K_t}{Y_t})^{\frac{\alpha}{1-\alpha-\beta}}.(\frac{H_t}{Y_t})^{\frac{\beta}{1-\alpha-\beta}} \tag{1.16}$$

In the above equation, H represents the stock of human capital. This specification is similar to Mankiw, Romer and Weil (1992) [59]. Using Equation 1.16, we can decompose the output-per-worker growth into the growth in productivity parameter A and the combined factor accumulation growth (i.e. the weighted sum of K and H growth).[10]

[10] Klenow and Rodriguez (1997) mention in detail the benefits of this form compared to the other transformation of the production function which has $(\frac{X}{L})$ on the right hand side.

If using intangible H as a direct input to the production function does not sound realistic, we can think of the human capital stock H as $H = h * L$ with h representing the human capital per worker. Then the production function in Equation 1.16 can be rewritten as $Y = K^{\alpha} * (\bar{A}L)^{1-\alpha}$, where $\bar{A} = h^{\beta*(1-\alpha)} * A^{\frac{(1-\alpha-\beta)}{(1-\alpha)}}$. $\bar{A}$ is sometimes referred to as *efficiency units* of the labor.

Following Mankiw, Romer and Weil (1992) [59], the paper uses education enrollment rates as a measure of $(\frac{I_H}{Y})$. [11] The series for stock of human capital is constructed using the approach employed by Barro and Lee (2000) [9] and a measure of investment in human capital. Analogous to the physical capital accumulation process, the paper assumes that the student population enrolled in the schools at various education levels is accumulated as human capital of the workforce. There can be a valid criticism of using the enrollment rate as a *measure* of investment rather than a *proxy* for the investment, because it is possible that all the investments into human capital/ education initiatives do not translate one-to-one into increased education enrollment. But since we are interested in *quantity* series and not the *volume* series, it should not be an issue, since if during any period the investment in human capital is higher even though the education enrollment has not changed, it just means that the *price* of the human capital has changed between the periods.

The paper generates four different human capital stock series based on enrollments in different levels of education: primary, secondary, post-secondary and enrollment at any level (i.e. sum of primary, secondary and post-secondary). The growth of $\frac{H}{Y}$ is plotted in Figure 1.9 along with the productivity movements.

Human capital stock (using primary education) grows at around 2% from the 60s to early 70s, and then starts falling resulting in negative growth rate between late 70s and mid 90s (Panel A). As a result, $\frac{H}{Y}$ ratio falls back to its starting value 1.5 (Panel B).

The paper uses the same parameter values for production function as in Mankiw, Romer and Weil (1992) [59]; which are $\alpha = 0.3$ and $\beta = 0.28$. Labor productivity growth rate estimates for different human capital investment measures are shown in Table 1.6 (along with HP filtered series growth rates).

The average annual productivity growth rates vary between -0.07% and 2.68% depending on the measure of human capital investment used. The estimates using secondary education as the measure are close to earlier esti-

[11] MRW do not need to construct the human capital series, since they explain output per worker variations across countries.

mates (with only physical capital). The main results of the previous section in regards to period-wise trends in productivity growth are reinforced by these calculations. Productivity growth was negative in the 60s and 70s. It turned around in the 80s and the growth rates have been increasing ever since.

The reason for productivity being higher when using only post-secondary education is that $\frac{H}{Y}$ estimates are too low. And since the growth in Y is faster than the growth in post-secondary completed, all the increase in the output results from productivity increase. Similar and reverse logic goes for productivity estimates being too low when using sum of all levels of education.

Panel A in the figure highlights the period-wise trends in input, output and productivity growth rates. Distinction between **pre-reform** and **post-reform** periods is very clear. Physical and human capital growth was high in the 1960s and 1970s, but due to the negative productivity growth, that input growth did not result in high output growth. On the contrary, the period following 1980s experienced a decline in input growth rate, but productivity started growing at a very fast rate leading to increased output growth.

The paper performs the variance decomposition using different human capital measures. The results are reported in Table 1.7. One interesting result is that when the sum of all levels of education is used as the measure of human capital, input variations can explain up to 83% of the variations in output. That means that productivity changes were responsible for only 17%. Compared to only the physical capital case, this result fits the usual neo-classical vs. technological progress debate in the sense that accounting for unmeasurables (using education as proxy for human capital) reduces the unexplained share attributed to residuals.

Just as previously, the success criteria S1 and S2 give more sensible results than KR. A consistent negative value of KR in growth is due to the fact that India experienced accelerated input and output growth in different periods. While 1961-1980 were the periods of high growth in factor accumulation, output was growing at slower rates during that time because of falling productivity. Following the 1980s when productivity started to pick up, the earlier high rate of growth of input could not be maintained. But this upward trend in productivity was large enough to keep increasing the output growth rates.

1.6 Return on Education

The growth in different levels of education has been very different in India. In fact, this is one of the distinguishing features of the Indian economy. As the previous section shows, using different measures of schooling as human capital indicator gives different TFP growth estimates. This non-similar growth in different levels of education makes the sectoral studies like Bosworth, Collins and Virmani (2007) [18] inaccurate. The distribution of workers with primary, secondary and post-secondary education among different sectors of economy is very varied, with the service sector employing a higher portion of the post-secondary educated workforce than the agriculture sector. But for studying the aggregate Indian economy, we can solve the problem of differential growth pattern among education levels by creating a combined indicator of human capital based on *all education levels*. Each education level is weighted by its relative importance in the production process. The most obvious way of measuring this relative importance is to estimate how much difference does each year of education (primary, secondary or post-secondary) make in a worker's productivity. Since workers' wages are based on their productivities, we can use the results from the labor market literature on *return to education* to get these weights.

Using Hall and Jones (1999) [46], the production function with labor augmenting technology parameter can be written as -

$$Y_t = K_t^{\alpha}(A_t H_t)^{1-\alpha} \tag{1.17}$$

H is the human capital augmented labor; $H_t = e^{\phi(E_t)} L_t$. $\phi(E_t)$ represents the quality of labor and is a function of the number of years of schooling E_t. $\phi(E_t)$ is a piecewise linear function.

$$\phi(E_t) = \begin{vmatrix} e_1^t \\ e_2^t \\ \\ e_N^t \end{vmatrix} . \begin{vmatrix} w_1 \\ w_2 \\ .. \\ w_N \end{vmatrix} \tag{1.18}$$

Since data series are available for both the enrollment and completion of each of the education level, the array for number of years of education is formed based on Indian education system. The primary education level takes 4 years to complete, secondary education is another 4 years and post-secondary requires another 4 years. For students who enroll in a level but do not complete it, we can assume that the average schooling on that education level is 2 extra years; i.e. on average the dropout happens midway through that level.

The parameter array W (which is equal to $\phi'(E)$) is the result of Mincerian regression estimating the return to schooling. For India, there are two such influential studies: Psacharopoulos and Patrinos (2002) [66] and Duraisamy (2000) [33]. The paper uses both these sets of coefficients. Psacharopoulos estimates for returns on investment in each year of education are 13.4% for the first 4 years (primary), 10.1% for the next 4 years (secondary) and 6.8% for each year after that (post-secondary); while Duraisamy coefficients are 8.2%, 8.4% and 13.7% respectively.

The main difference between these two sets of estimates is the return on post-secondary schooling (which experienced high growth in earlier years) compared to the return on primary education (which had very modest growth). Duraisamy coefficients indicate that the investment in post-secondary education yields higher return than the investment in primary education, while Psacharopoulos estimates suggest the contrary. If for India the return on investment in post-secondary education is higher than the return on investment in primary education (as pointed by Duraisamy), then it was a wise policy decision to concentrate on higher education in the 1960s and 1970s.[12]

The production function in Equation 1.17 can be rewritten as

$$(\frac{Y_t}{L_t}) = (\frac{K_t}{Y_t})^{(\frac{\alpha}{1-\alpha})} * (\frac{H_t}{L_t}) * A_t \tag{1.19}$$

The paper creates two human capital stock series and then performs two sets of exercises (growth accounting and variance decomposition). Calculated human capital productivity estimates and period-wise growth rates are shown in Table 1.8.

Average annual growth rate is 0.7% to 0.9% which is very close to the earlier average growth rate obtained using MRW method for primary completed. Period-wise average productivity growth rates calculated using this method behave in exactly the same way. Starting from slightly negative values in the 60s, growth rates decreased in the 70s before turning around to positive rates in the 80s and then growing since the 90s. Duraisamy has a lower return on education and hence lower $\frac{H}{L}$ value. This results in slightly higher human capital productivity growth estimates. Figure 1.10 plots human capital productivity growth. The value of human capital $\frac{H}{L}$ grows from around 1.1 in 1961 to 1.4 - 1.6 in 2004.

[12]Even though the coefficients are the return on education to individual workers, one can think of them as indirect return on public investments in education.

The estimated productivity growth rate trends using MRW method (with combined completion rate as measure of H) are very similar to the ones calculated using HJ method except for initial periods (Panel A). Results of different variance decompositions are shown in Table 1.9. In levels, input changes account for 55% to 63% of the output changes, thus reducing the role of productivity changes when compared to the case of only physical capital. As earlier, the results of KR decomposition in growth rates are not informative.

1.7 It is Inspiration and not Perspiration

A country can increase its output either by working more hours, saving a lot, training its workers (*perspiration*) or it can find better ways of producing things and improve its policies and resource allocations (*inspiration*). The results in this paper point out that the growth in the Indian economy is driven more by inspiration and not by perspiration. Figure 1.11 plots the estimated values of productivity parameter A for all the different specifications of H used in this paper. These are not the smoothed TFP growth rate plots. This summary figure shows how $logA$ (i.e. $log(\frac{Y}{L}) - \alpha * log(\frac{K}{L}) + \beta * log(\frac{H}{L})$) is flat or goes down in the 1970s before turning around in 1980s and then accelerating in 1990s.

These results indicating that total factor productivity growth is responsible for the surge in Indian economic growth might seem surprising. The objections to the presence of total factor productivity growth as in Jorgenson and Griliches (1967) [50] are somewhat valid. But aggregating the production activities of the whole economy is a challenging task. Apart from the usual issues faced when combining different types of units (input and output factors, production processes), Cobb-Douglas production function used in the literature is a simplistic approximation to represent all the different activities taking place in an entire nation. It is true that accounting for an extra input reduces the *Solow residuals*, but it does not prove that large efficiency improvements/ or high TFP growth cannot occur.

In 1970s, operating a business services company in India required applying for licenses for almost everything. This not only reduced the output of that company (due to time wasted in waiting), but also had spill-over effects. For example, another business establishment that uses the services of this company as intermediate but required services also had to wait. Once the government interventions were abolished in 1991, the same business was able to produce more services per worker without requiring any extra labor, without any extra investment (capital or R & D), and without any *measurable quality improvements in any of the inputs.* Even on aggregate level, government did not have to make any public investment to make this happen. There is no way that any modification to the K input or the L input can explain this growth and it should not, as the growth is **not** happening because of increased input.

It is this type of growth that appears as TFP growth in the case of the Indian economy. In the 1960s and 1970s (when the economy was weak), government-led industrialization and education policies made it possible for India to accumulate human and physical capital at a faster rate. But at the same time, increased government regulations restrained the productivity growth. In fact, negative TFP growth estimates in the 1970s mean that the productivity went down. Once the restrictions were removed in 1990s, the output started growing rapidly due to efficiency gains despite having no significant increase in input accumulation growth rates. The ongoing debate on the topic of 1980s vs. 1990s seems valid because the 1980s is the period of inflection, as can be seen in the TFP levels (Figure 1.11) and also in the HP filtered TFP growth rates (Figures 1.6, 1.9 and 1.10). In 1980s the TFP growth trend stopped becoming more negative and turned to positive. But the average growth rate in the 1980s is much smaller than the average growth rate in the 1990s. It seems that the 1980s were spent in undoing the damage done during the 1970s in terms of the productivity decline.

1.7.1 Quality of Capital and Other Issues

The set of results discussed in the paper suggests that the large jump in TFP growth rates does not represent capital-equipment-embedded technological change. Investment specific technological progress can play a significant role in GDP growth as pointed out by Greenwood, Hercowitz and Krusell (1997) [44]. They argue that the relative price of equipments goes down due to technological advances and it leads to increased accumulation. For the Indian economy, the price of capital good[13] relative to the consumption good is shown in figure 1.4. The relative price of K kept increasing for the period between mid-1960s and 1991. During this time the growth of K-accumulation (as shown in figure 1.6) remained constant. Even though the relative price for capital-good went down in the post-reform period, this drop is not accompanied by an increased K accumulation rate. A sector-wise analysis can not be performed for the aggregate Indian economy because of

[13] Greenwood, Hercowitz and Krusell (1997) [44] talk about only the equipments. But for India, price data by types of capital is not available.

the data issues. But as Domar (1963) [31] argues, the improving quality of capital should not account for a significant part of the growth of the residuals at aggregate level. In general, if the quality of capital goods has increased at a faster rate than the quality of output, then the TFP growth rates obtained using unadjusted Y and K growth rates might be higher. This is what Hulten (1992) [48] finds out for the US data.

But notice that a 1% underestimation of Y growth adds to the residual one-for-one while the underestimation of K growth decreases the residuals only by a factor of one-third.

$$\Delta lnA_{quality-adj.} = \Delta(\frac{Y}{L})_{quality-adj.} - 0.3 * \Delta(\frac{K}{L})_{quality-adj.} \tag{1.20}$$

For India, the data for quality adjusted price indexes is not available and hence the paper can not perform this analysis. But as mentioned earlier, input and output accelerated in different periods. Then these quality adjustments[14] will make the difference between pre-reform TFP growth rates and post-reform TFP growth rates even larger.

There are other (more direct) measures of technological progress e.g. number of patent applications. TFP growth rate indicates the ability of an economy to produce more output from the given set of inputs. Technological improvements will definitely show up as TFP growth (even after accounting for R & D input), but TFP growth can come from other sources as well. For example, in their analysis of Green Revolution, Murgai, Ali and Byerlee (2001) [61] find that there is a time-lag between adoption of technologies and realization of productivity gains and this is related to efficiency gains. Lanjouw and Cockburn (2000) [57] use survey data from India and find some (limited) evidence of an increase in patents and allocation of research for patents, but it appears to have leveled off in the 1990s. Hence, the TFP numbers and specially the jump in its growth rates and the turnaround in its trend can not be explained entirely by the technological progress.

This growth analysis should make the policy makers happy. Because unlike capital accumulation driven growth, TFP driven growth is not subject to decreasing return to scale. But on the other hand, it becomes more difficult to improve the efficiency any further as the country becomes more efficient. For example if one is already at the frontier of technology, the efficiency cannot go up. The same is true for total factor productivity as well. The other worrying part is that even if India can continue to improve

[14] If we implicitly assume that quality of capital is growing at constant rate

on some of its economic processes and production blueprints, it is still going to waste a huge part of its workforce (labor input). Put another way, right now India is under-utilizing its labor capacity by not including many of the workers in the production process. If it does (which would require huge investments), it can grow along the production function even in the absence of any technical progress or TFP gains.

TFP growth and factor accumulation growth are not mutually exclusive. One moves the production possibility frontier ahead, while the other moves along it by achieving those possibilities. TFP growth is much more difficult to attain and that explains why very high TFP growth estimates are often treated with skepticism. India has already done the tough job and improved its economic efficiency by reforming many of the markets. It is the relatively easier task of expanding the economy along this improved production possibility frontier that remains to be done. High unemployment or under-employment means that the Indian economy is operating well below its *potential output*. An expansion of labor input combined with the capital investment (so that the capital-per-worker ratio does not fall) is required to help India achieve its potential output. It will also make the growth more *inclusive* by increasing the percentage of population (i.e. employed workforce) that can reap the benefits of the gains in labor productivity.

1.7.2 TFP Growth as Residual Growth

One has to be cautious before making claims that Total Factor Productivity numbers represent the production potential of labor and capital inputs. Since TFP growth is estimated as the residual growth (output growth beyond the growth in capital and labor inputs), the estimated turnaround in TFP growth rates is a combined effect of several factors including advances in production technology, unmeasurable changes in input quality and improvements in economic institutions and market conditions. Hulten (2000) [49] talks about some of the limitations of TFP in explaining economic growth. The Indian case is especially susceptible to such criticisms because the acceleration in TFP growth coincides with the economic reforms and the service sector boom. Trade reforms, capital market reforms, advances in telecommunications technology and internet revolution made significant contributions in increasing the output produced by the Indian economy. Disentangling the individual effects of all these possible contributors is very hard (if not impossible).

The disaggregated numbers (Table 1.10 and Figure 1.13) show that the output growth was very high in service sector. The share of service sector in total investment (and thus total capital formation) has been increasing. Since traditional growth accounting results do not take care of shift in the shares, the observed TFP growth surge also includes this *"reallocation"* to more productive service sector. If investment and labor series by different sector is available, we can use bottom-up approach by doing the industry-level growth accounting and then estimate how much of the aggregate TFP growth is due to the reallocation of factors.

Rather than debating factor accumulation vs. technological progress as the cause of economic growth, Fischer (1993) [37] uses a *regression analog* of cross-country growth accounting. His finding that inflation, deficits and distorted foreign exchange markets negatively effect the growth may explain the negative TFP growth in the 1970s. The improvements in these macroeconomic factors in India after 1990s may have helped the output growth and hence are part of estimated TFP acceleration. Acemoglu and Zilibotti (2001) [1] argue that many technologies transferred from developed economies to less developed countries require skilled workers and mismatch between skills and technology can lead to sizable differences in TFP. If technology transfer accelerated after economic reforms and due to expansion of telecommunication infrastructure, huge stock of existing skilled workers (accumulated through investment in tertiary education during the 1960s and 1970s) would have helped in making productivity gains from those technologies.

If state-wise estimates for aggregate labor and capital inputs are constructed, one can obtain the TFP growth numbers for different states. This approach can help us exploit the variations in TFP growth across states to look for the possible roles of different institutions and public policies. Currently such data is not available. This kind of state-wise aggregate TFP growth analysis would also help us find out the role of reallocation between states, where the input factors shifted from less productive states (e.g. Uttar Pradesh, Bihar) to more productive states (e.g. Maharashtra, Karnataka). This reallocation is also contributing to the aggregate TFP growth numbers obtained in this paper.

With these views in mind, the results of this paper should be interpreted as *increased factor accumulation did not cause growth surge in India* rather than *reforms in India caused TFP growth to go up.* Easterly and Levine (2001) [34] claim that "residual" (TFP) rather than factor accumulation can explain the cross-country income and growth differences and that the national policies are also associated with long-run growth rates. To estimate the exact contribution of different policies and reforms in India would be a difficult task and the data requirements for such an exercise would be huge.

Recently many of the statistical agencies and government departments have started digitizing their data and sharing it (free or for a price). The prospects of a more detailed analysis in near future look brighter.

1.8 Conclusion

The paper studies Indian aggregate macroeconomic data between 1961 and 2004 to identify period-wise growth trends and to find out how much of the changes can be explained by growth in capital accumulation. There seems to be a clear distinction between pre-1980s and post-1980s periods in terms of input, output and (calculated) productivity growths. In the first period, impressive input growth could not result in output per worker growth due to the negative productivity growth. In the later period, even with the slow input growth, economy experienced high growth in the output because of the increased productivity growth. Two of the most cited explanations, namely the market reforms in 1991 leading to a surge capital accumulation and India's stock of human capital in terms of skilled workers causing the growth, are not supported by the data. Most of the increase in growth is coming from the total productivity growth indicating the efficiency improvements in the Indian economy.

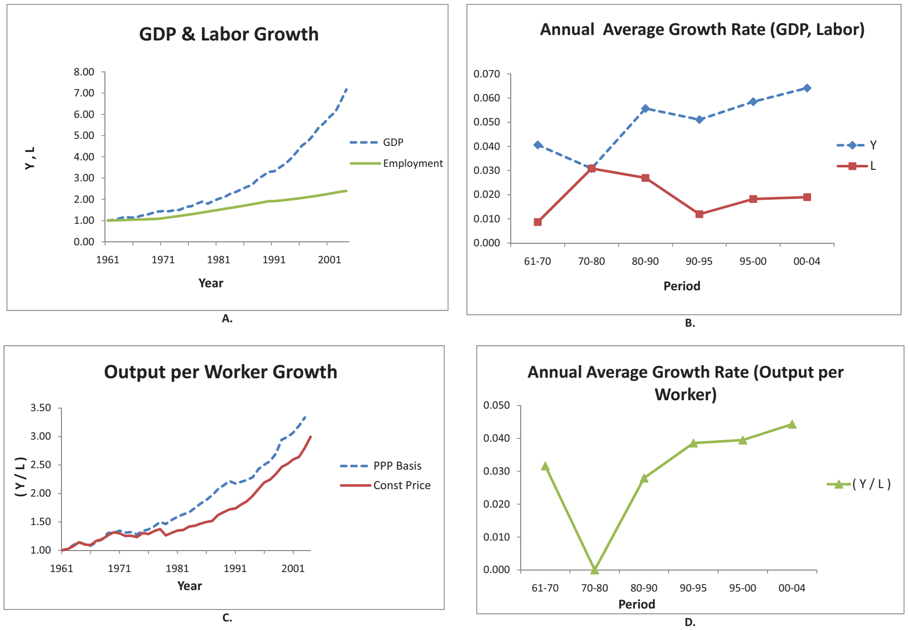

Figure 1.1: Output Per Worker Growth

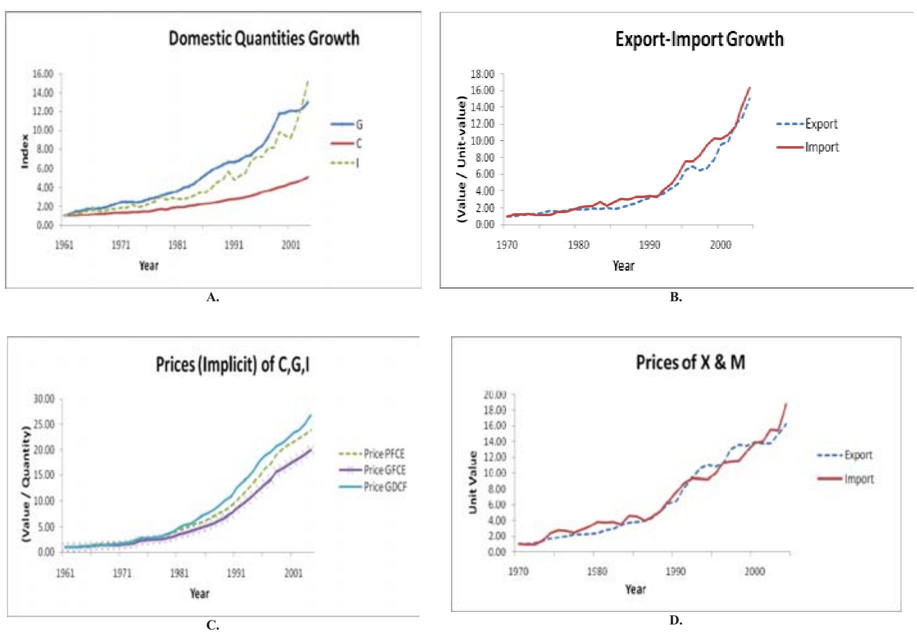

Figure 1.2: Quantities and Prices Growth

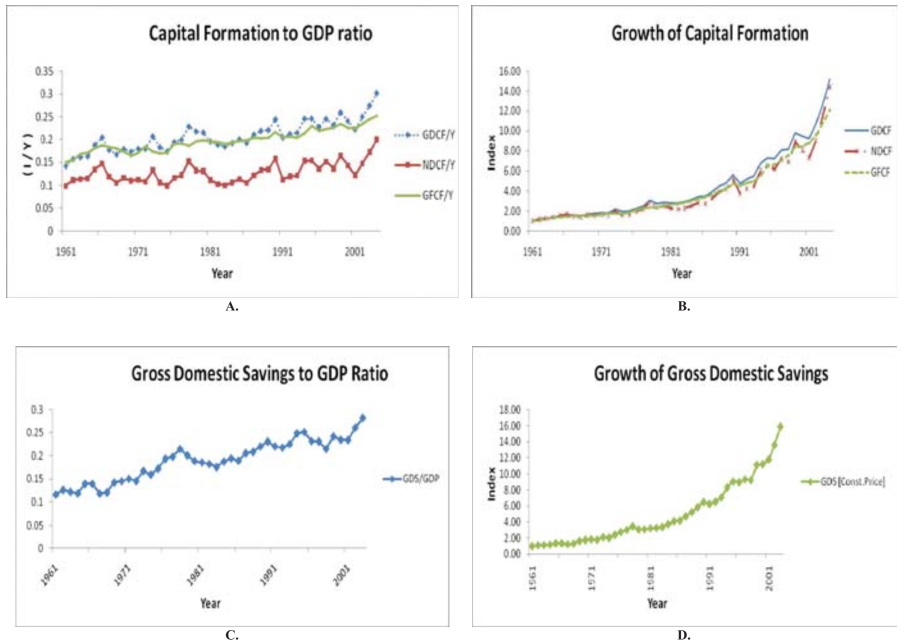

Figure 1.3: Capital Formation Growth

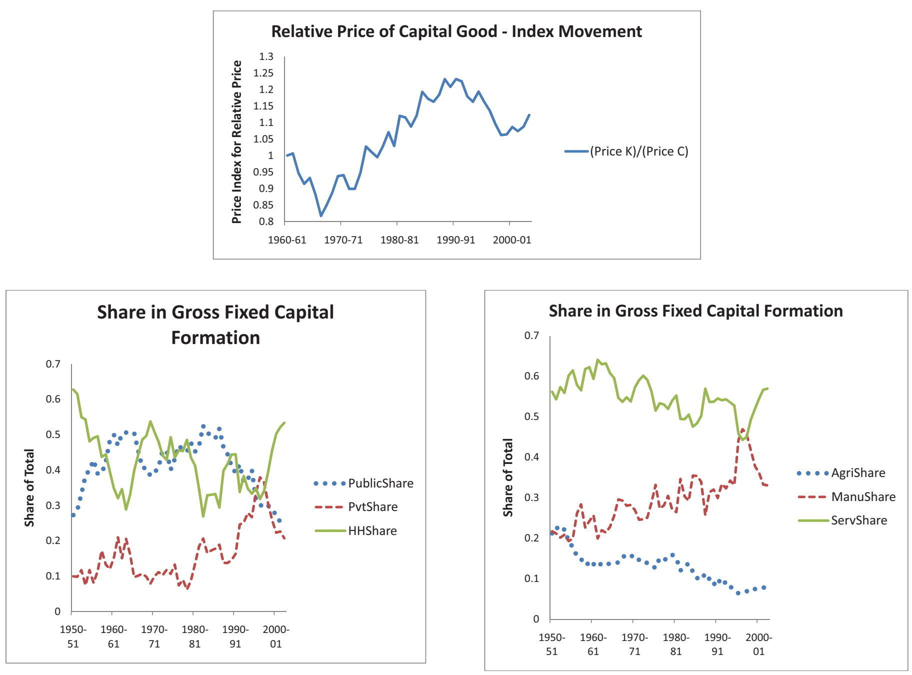

Figure 1.4: Capital Formation Shares

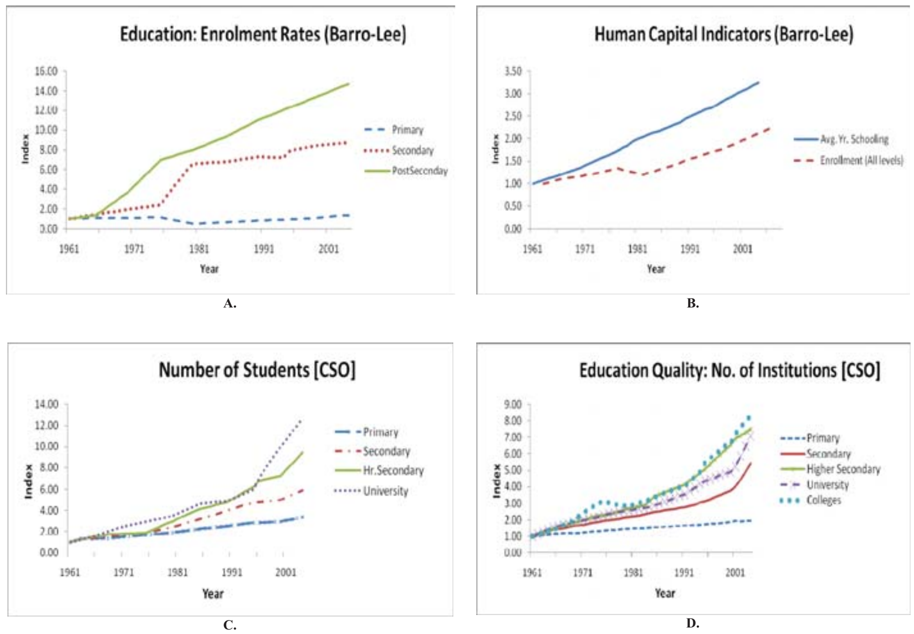

Figure 1.5: Growth in Measures of Education

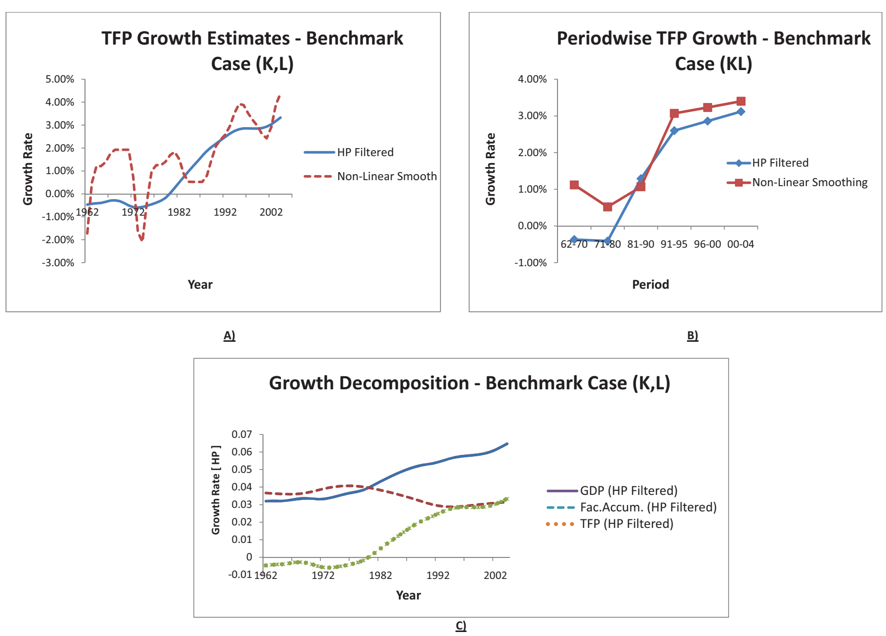

Figure 1.6: TFP Estimates: $Y = AK^{\alpha}L^{1-\alpha}$; α=0.3; $K_0 = 1.5Y_0$;

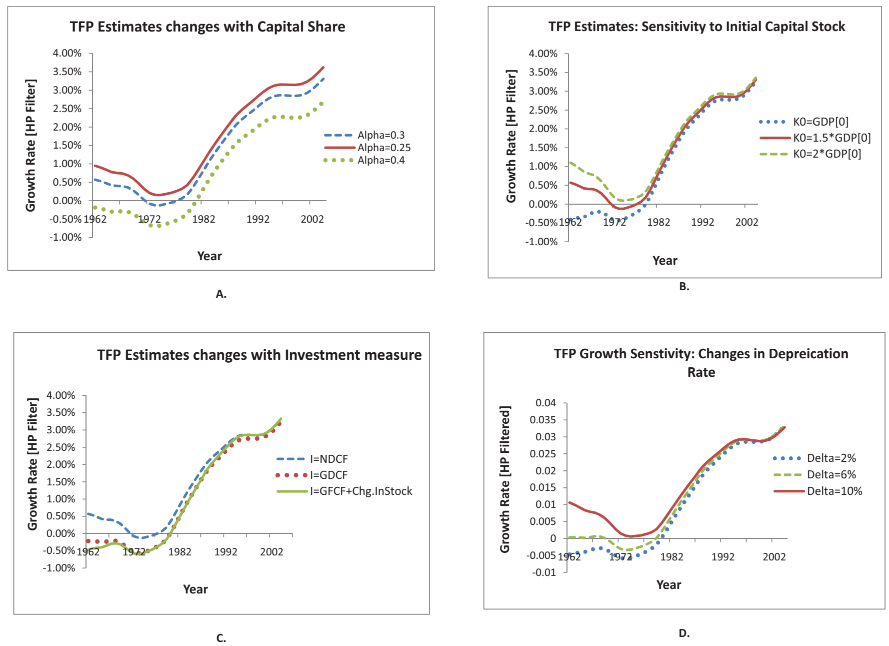

Figure 1.7: TFP Estimates: Robustness w.r.t. α, K_0, I Values

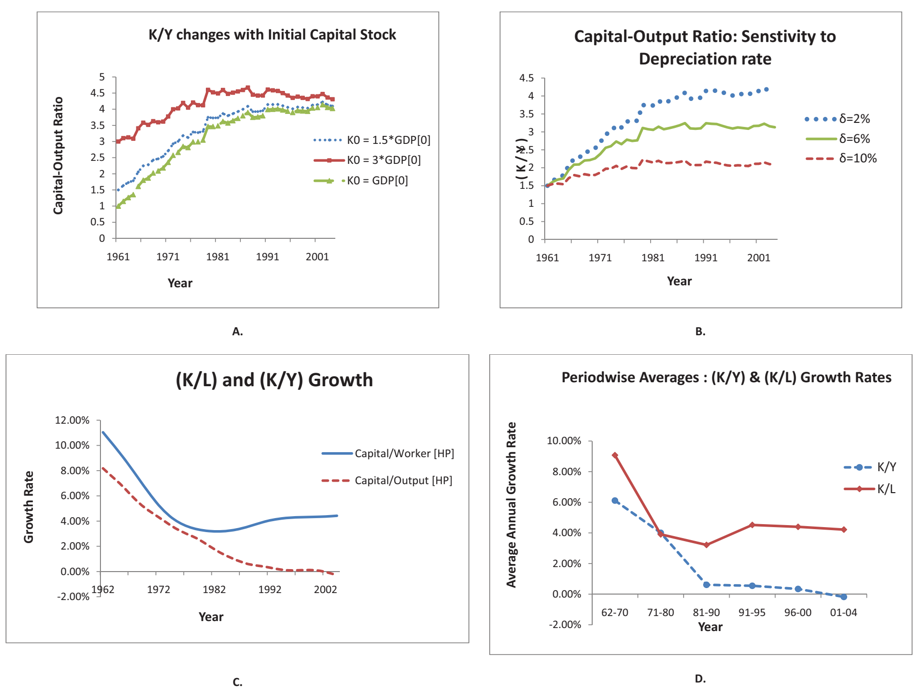

Figure 1.8: Capital Output and Capital Labor Ratio Growth

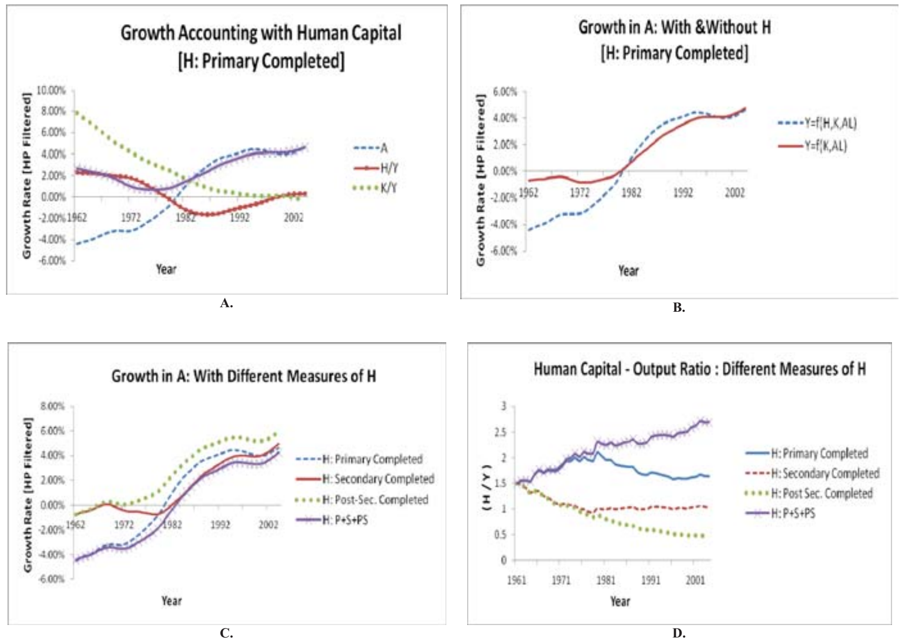

Figure 1.9: Human Capital Output Ratio & Labor Productivity Growth

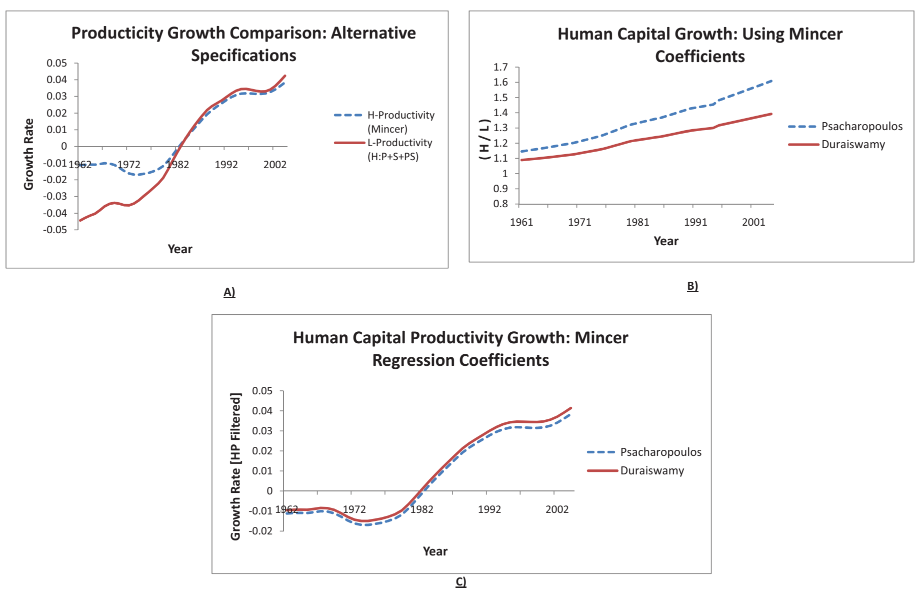

Figure 1.10: $\frac{H}{L}$ Ratio & H Productivity Growth: Mincer Coefficients

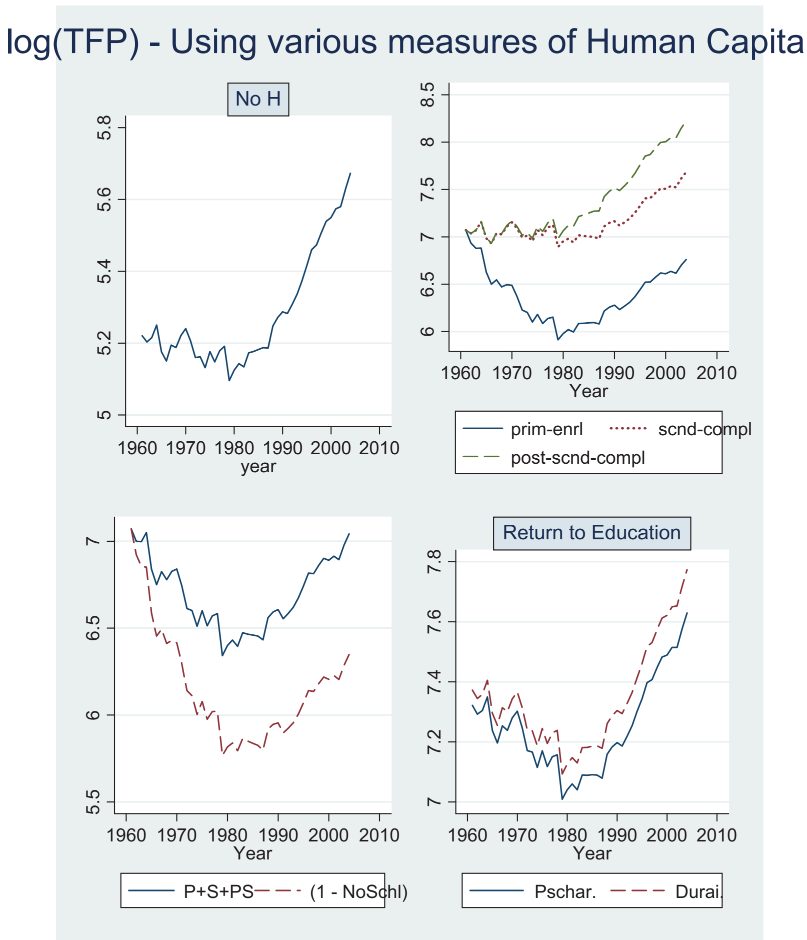

Figure 1.11: Productivity Estimates Summary - log(TFP), Using Different H

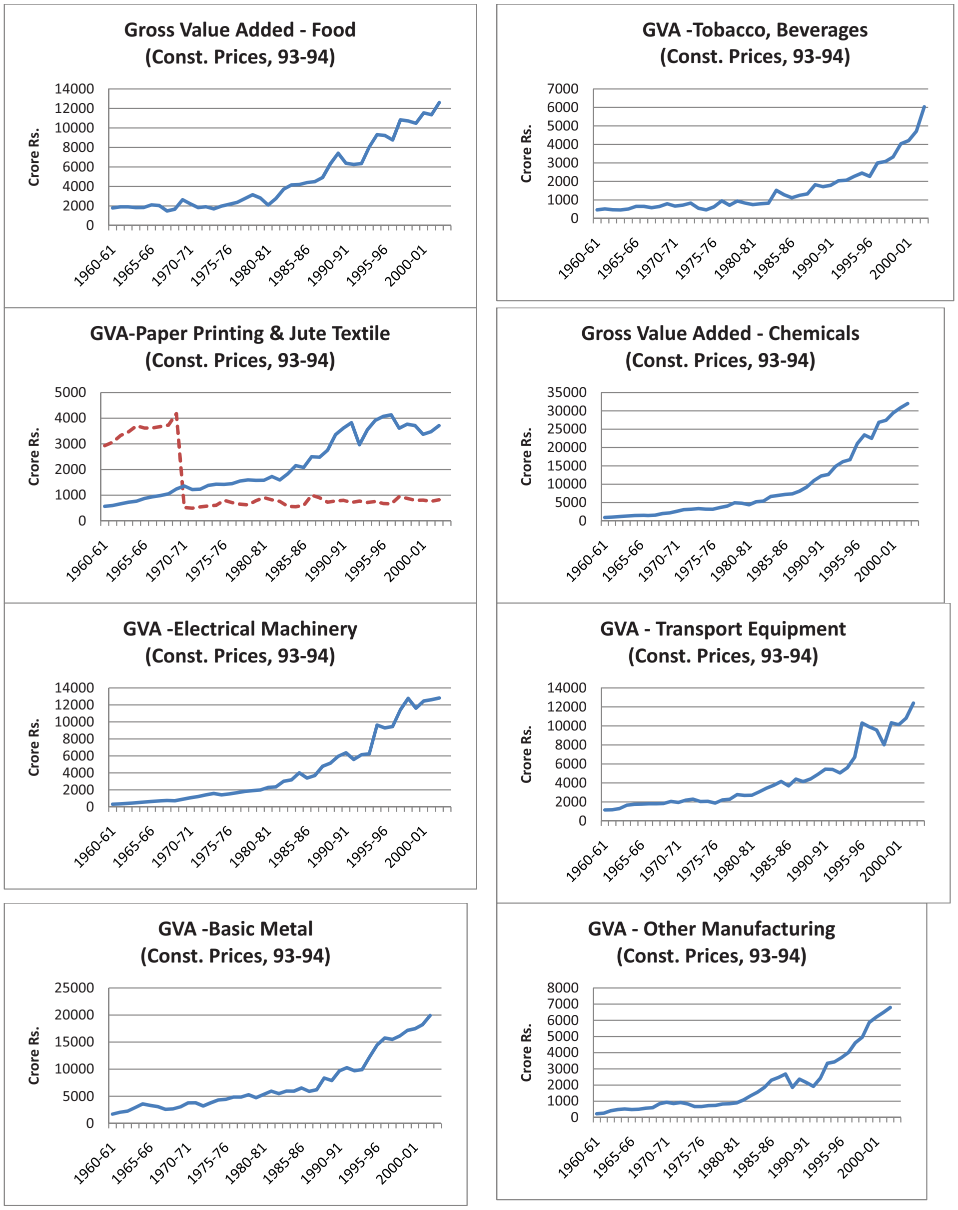

Figure 1.12: Gross-Val-Add Growth in Registered Manufacturing Industries

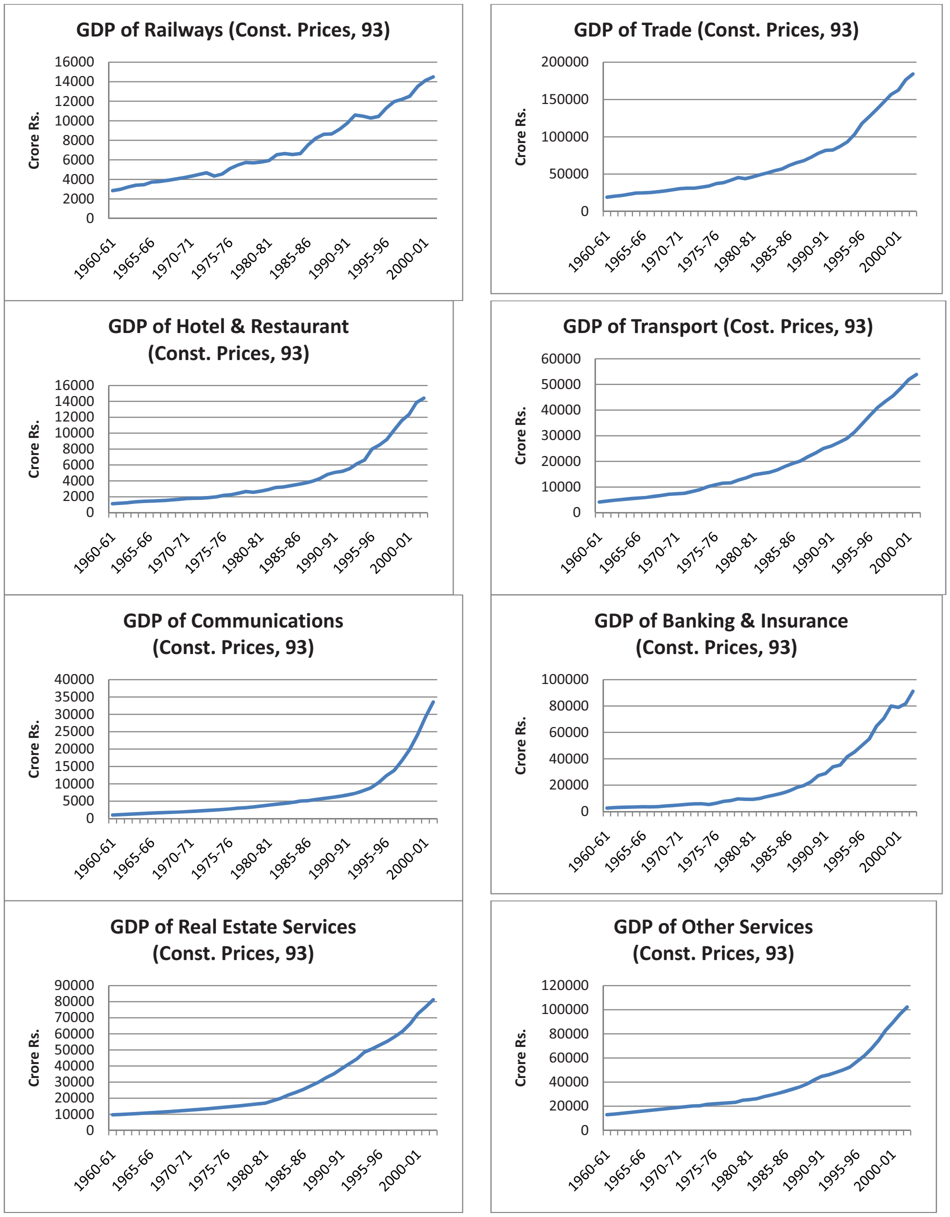

Figure 1.13: GDP Growth in Service Sector Components

	Overall (Average)	**Avg. Annual Growth Rate**					
	1961-2004	**61-70**	**71-80**	**81-90**	**91-95**	**96-00**	**01-04**
GDP (Y)	7.2 times (4.7%)	4.1%	3.1%	5.6%	5.1%	5.8%	6.4%
Labor (L)	2.4 times (2.1%)	0.9%	3.1%	2.7%	1.2%	1.8%	1.9%
Output per Worker ($\frac{Y}{L}$)	3 times (2.6%)	3.2%	0%	2.8%	3.9%	4%	4.4%
Pvt. Consumption (Q_C)	5.1 times (3.9%)	3.1%	3.4%	4.2%	3.9%	4.8%	5.1%
Govt. Consumption (Q_G)	13 times (6.3%)	9.6%	4.6%	6.8%	3.7%	8.3%	2.4%
Investment (Q_I)	15.2 times (6.9%)	6.6%	5.7%	7.1%	6%	5.8%	13%
Export[a b] (Q_X)	15 times (8.6%)	-	6.3%	6.3%	14.9%	8.7%	12.2%
Import (Q_M)	16.3 times (9.1%)	-	8%	6.1%	17.3%	6.5%	12.5%
Implicit P_C	23.9 times (7.8%)	6.6%	8.8%	8.4%	10.6%	7.2%	3.4%
Implicit P_G	20 times (7.3%)	4.2%	8.3%	9.1%	10.3%	6.7%	4.1%
Implicit P_I	26.8 times (8.1%)	5.8%	9.8%	10.2%	10.3%	4.7%	4.8%
Unit Value P_X	16.3 times (8.8%)	-	9.5%	10.6%	11%	5.4%	4.2%
Unit Value P_M	18.8 times (10%)	-	16.4%	7.9%	5.7%	6.9%	8.4%

[a]Total Growth between 1970-2004.
[b]Quantity is calculated using $\frac{TotalValue}{Unit-Value}$

Table 1.1: Growth of Macroeconomic Aggregates

	Overall (Average)	**Avg. Annual Growth Rate**					
	1961-2004	**61-70**	**71-80**	**81-90**	**91-95**	**96-00**	**01-04**
Gross Capital Formation (GDCF)	15.20 times (6.9%)	6.6%	5.7%	7.1%	6%	5.8%	13%
Net Capital Formation (NDCF)	14.45 times (7.4%)	5.7%	6%	8%	6.6%	5.3%	16.8%
Fixed Capital Formation (GFCF)	12.10 times (6.1%)	5.1%	5.1%	6.5%	6.7%	5.4%	9.5%
Gross Domestic Savings (GDS) [a] [b]	15.92 times (7.1%)	6.9%	6.2%	7.8%	7.1%	4.7%	12.5%

[a]Converted to constant price series. See appendix A for details.
[b]Total Growth between 1961-2003.

Table 1.2: Growth in Physical Capital Formulation

	Overall (Average)	**Avg. Annual Growth Rate**					
	1961-2004	**61-70**	**71-80**	**81-90**	**91-95**	**96-00**	**01-04**
Avg. Years of Schooling[a]	3.25 times (2.7%)	3.4%	3.7%	2.3%	2%	2.3%	1.9%
Primary Attained	1.37 times (1%)	0.9%	-6.8%	5%	2.4%	4%	4.6%
Secondary Attained	8.79 times (5.4%)	7.8%	13.4%	1%	1.7%	1.4%	0.8%
Post-Secondary Attained	14.73 times (6.7%)	15.9%	8.3%	3.2%	2.3%	2.1%	1.9%
Some Schooling [b]	2.22 times (1.9%)	2.1%	0%	2.8%	2.1%	2.7%	2.4%
Primary Scholars/ Students [c]	3.37 times (3%)	4.4%	2.7%	2.8%	2.4%	0.7%	3.6%
Middle-Secondary Scholars	5.94 times (4.3%)	5.6%	4%	5.1%	3.8%	0.9%	4.4%
Higher-Secondary Scholars	9.42 times (5.4%)	6.7%	5.4%	4.9%	5.5%	3%	6.8%
University Scholars	12.67 times (6.1%)	10.1%	4%	3.4%	4.2%	10.9%	6.1%
No. of Primary Schools	1.96 times (1.6%)	2%	1.9%	1.2%	1.2%	1.6%	1.2%
Middle-Secondary Schools	5.4 times (4%)	5.8%	2.7%	2.3%	2.9%	3.8%	9.5%
Higher-Secondary Institutions	7.49 times (4.8%)	7.4%	3.5%	4.2%	4.8%	5.1%	3.5%
Universities	7.08 times (4.7%)	7.6%	2.8%	3.1%	4.8%	2.4%	9.7%
Colleges	8.31 times (5.1%)	9.1%	2.7%	3.4%	6.6%	3.8%	6.1%

[a] Barro-Lee Database. Missing values are generated using linear trends.
[b] This is calculated using (100 - Percentage with No Schooling)
[c] Source: Central Statistical Organization, India.

Table 1.3: Growth in Education and Human Capital Measures

	Avg. Annual Growth Rate of A						
	1961-2004	**61-70**	**71-80**	**81-90**	**91-95**	**96-00**	**01-04**
$(\frac{Y}{L}) = A(\frac{K}{L})^{\alpha}$ **: Hicks-Neutral TFP**							
No Smoothing	1.05%	0.22%	-1.16%	1.63%	2.57%	2.95%	3.08%
HP Filter	1.05%	-0.37%	-0.41%	1.29%	2.60%	2.85%	3.12%
$(\frac{Y}{L}) = A(\frac{K}{Y})^{\frac{\alpha}{1-\alpha}}$ **: Labor-Augmenting TFP**							
No Smoothing	1.50%	0.32%	-1.65%	2.32%	3.67%	3.83%	4.40%
HP Filter	1.50%	-0.53%	-0.58%	1.84%	3.72%	4.08%	4.45%

Table 1.4: Periodwise Estimates: TFP Growth with No H Specification

	Levels			**Growth Rates**		
	KR	**S1**	**S2**	**KR**	**S1**	**S2**
$X = (\frac{K}{L})^{\alpha}$	0.52	0.31	0.70	0	0.039	0.58
$X = (\frac{K}{Y})^{\frac{\alpha}{1-\alpha}}$	0.31	0.18	0.59	-0.43	0.26	0.36

Table 1.5: Variance Decomposition: Share Explained by Capital Accumulation

	Avg. Annual Growth Rate of A						
	1961-2004	**61-70**	**71-80**	**81-90**	**91-95**	**96-00**	**01-04**
H: Primary Completed							
No Smoothing	0.7%	-2.45%	-3.78%	3.50%	3.81%	3.77%	4.29%
HP Filter	0.7%	-3.73%	-2.06%	2.50%	4.26%	4.17%	4.30%
H: Secondary Completed							
No Smoothing	1.43%	0.92%	-2.01%	2.13%	3.24%	3.57%	4.47%
HP Filter	1.43%	-0.28%	-0.54%	1.35%	3.57%	3.97%	4.50%
H: Post-Secondary Completed							
No Smoothing	2.68%	1.09%	-1.06%	4.54%	4.83%	4.89%	5.52%
HP Filter	2.68%	-0.15%	0.56%	3.62%	5.27%	5.28%	5.54%
H: Any level Completed (Pr.+Sc.+PostSc.)							
No Smoothing	-0.07%	-2.57%	-4.40%	2.07%	2.72%	2.95%	3.79%
HP Filter	-0.07%	-3.84%	-2.74%	1.13%	3.14%	3.36%	3.80%

Table 1.6: Period-wise TFP Growth: Using Human Capital (MRW)

	Levels			Growth Rates		
	KR	**S1**	**S2**	**KR**	**S1**	**S2**
$X = (\frac{K}{Y})^{\frac{\alpha}{1-\alpha-\beta}}$	0.51	0.49	0.71	-0.52	0.73	0.60
$X = (\frac{H}{Y})^{\frac{\beta}{1-\alpha-\beta}}$						
H: Primary Completed	-0.07	0.04	0.50	-0.62	0.53	0.17
H: Secondary	-0.14	0.07	0.53	-0.52	0.53	0.25
H: Post-Sec.	-0.77	0.69	0.86	-0.53	0.43	0.81
H: Pr.Cmpl.+Sc.+PostSc.	0.32	0.14	0.58	-0.62	0.46	0.34

Table 1.7: Variance Decomposition: Share Explained by Input X

	Avg. Annual Growth Rate of A						
	1961-2004	**61-70**	**71-80**	**81-90**	**91-95**	**96-00**	**01-04**
$\phi(E)$**: Psacharopoulos**							
No Smoothing	0.71%	-0.22%	-2.62%	1.57%	2.92%	2.91%	3.51%
HP Filter	0.71%	-1.10%	-1.46%	1.06%	2.92%	3.17%	3.53%
$\phi(E)$**: Duraisamy**							
No Smoothing	0.93%	-0.06%	-2.40%	1.78%	3.13%	3.20%	3.80%
HP Filter	0.93%	-0.93%	-1.26%	1.27%	3.16%	3.46%	3.83%

Table 1.8: TFP Growth: with Mincer Regression Coefficients (HJ)

	Levels			**Growth Rates**		
	KR	**S1**	**S2**	**KR**	**S1**	**S2**
$X = (\frac{K}{Y})^{\frac{\alpha}{1-\alpha}}$	0.31	0.18	0.59	-0.31	0.26	0.35
$X = (\frac{H}{L})$						
$\phi(E)$: Psacharopoulos	0.32	0.12	0.58	0	0	0.34
$\phi(E)$: Duraisamy	0.24	0.07	0.54	0	0	0.25

Table 1.9: Variance Decomposition: Share Explained by Input X; H Using Mincer Coefficients (HJ)

Industry	**1970-79**	**1980-89**	**1990-99**	**2000-02**
Food products	5.82%	9.04%	6.21%	6.50%
Bev - tobacco	4.82%	6.66%	7.17%	14.81%
Textiles	6.01%	5.40%	5.73%	2.01%
Wood - products	2.53%	5.14%	4.61%	-0.38%
Paper - printing	5.39%	9.41%	2.08%	-0.17%
Leather, fur, etc	6.46%	8.20%	6.44%	1.57%
Rubber - pet products	16.47%	13.68%	6.67%	9.18%
Chemicals	10.52%	6.62%	5.49%	5.70%
Non-metalic mineral	4.20%	11.75%	7.39%	9.72%
Basic metals	7.19%	6.72%	5.45%	7.09%
Metal products	2.80%	5.75%	7.24%	1.80%
Machinery (Elec + Non)	9.08%	9.82%	7.41%	3.22%
Transport equipment	4.22%	9.10%	10.29%	12.73%
Electricity	7.37%	8.48%	6.44%	3.67%
Gas	11.70%	24.47%	15.86%	11.31%
Water supply	9.10%	8.96%	7.43%	4.64%
Construction	2.76%	4.83%	4.93%	6.25%
Trade	5.17%	5.92%	7.54%	5.92%
Hotels - restaurants	5.24%	6.53%	9.71%	8.52%
Storage	10.08%	2.69%	1.81%	2.55%
Communications (Pub)	6.42%	5.94%	15.29%	18.94%
Railways	3.64%	4.52%	3.45%	6.77%
Road transport	5.74%	7.22%	7.48%	5.97%
Water transport	13.38%	5.36%	5.91%	6.36%
Air transport	5.54%	6.28%	3.51%	0.20%
Services incidental	58.60%	8.53%	7.60%	7.28%
Banking	9.07%	11.92%	12.72%	6.33%
Insurance	9.09%	10.97%	9.98%	11.37%
Real Estate	3.38%	3.82%	4.79%	6.18%
Business services	11.38%	13.48%	19.54%	24.87%
Legal services	7.38%	8.62%	5.79%	6.78%
Education	3.11%	6.50%	8.44%	9.67%
Research - scientific	4.41%	6.15%	13.38%	13.51%
Medical - health	4.54%	7.39%	7.62%	5.73%
Recreation + radio	2.18%	2.77%	2.70%	31.33%
Personal services	-0.08%	2.36%	5.21%	6.78%
Community Services	3.76%	6.55%	8.42%	9.02%

Table 1.10: Average Growth Rate of Various Industries

Chapter 2

Productivity Estimates and Growth Trends in Indian Manufacturing

2.1 Introduction

This paper studies the growth performance of Indian manufacturing industries between 1970 and 2003. These have been very interesting and transforming years for aggregate Indian economy. How has Indian manufacturing performed during this time? The answer to this simple question is not clear. There have been many research studies, but no consensual picture has emerged in the literature. Some of the reasons for this lack of consistency are poor data availability (until recently), debate about accuracy of different measures, choice of deflators and accounting methods used. Hulten and Srinivasan (1999) [47] summarize the scenario by stating “this is an area where tyranny of numbers has asserted itself with great force” and rightly so.

The inability to come up with reproducible growth estimates has been hampering the research on other topics as well. Any discussion on questions such as why the growth in Indian manufacturing was lower than in Chinese manufacturing or than in India’s service sector requires robust estimates of growth rates and period-wise trends. But different studies on Indian manufacturing industries, despite using the same data source, have come up with very different growth estimates.

Ahluwalia (1991) [2] observed a decline in total factor productivity (TFP) at the rate of 0.3% per annum over the period of 1965-66 to 1979-80. Goldar (1992) [40] reported that total factor productivity growth for the organized manufacturing sector was 1.55% per annum over the period of 1970-71 to 1980-81, which rose to 3.85% during 1980-81 to 1985-86 and further to 5.05% per annum during 1985-86 to 1990-91. To show the widespread differences between the results of different studies, Goldar (2002) [42] tabulates TFP growth estimates from several studies. These estimates vary between -1.2% and 3.4% per annum for the 1980s and between -0.3% and 5.5% per year for 1970s, which is not very helpful.

To be fair, the argument is sometimes about which methodology to use, but the confusion regarding the choice of deflators or which output measure to use (gross output or net-value-added) makes the situation worse. Similar discrepancies are involved in estimation of capital stock series, because most of the researchers do not explain how they create capital input series. Use of *capital services* concept as recommended in OECD manual on measuring capital [67] is not common in the previous studies on Indian manufacturing. Lack of transparency in explaining the data construction and failure to follow the standard methods have given rise to general skepticism towards Indian manufacturing studies.

This paper calculates a large set of estimates using two sets of productivity measures (based on gross output and based on net-value-added) and three different productivity analysis methods (traditional growth accounting, index numbers, envelopment analysis). This detailed exercise is performed with the following questions in mind: How much did the Indian industry grow in different periods? Did the growth occur due to input growth or due to TFP growth? How is this growth distributed across industries and across public versus 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? What are the aggregate trends in input, output and TFP growth rates?

The paper uses recently released Annual Survey of Industries dataset for the period between 1970 and 2003 to answer the above questions. The paper discusses the results obtained using the standard productivity accounting methods outlined in OECD productivity manual (2001) [38]. These estimates are not only more accurate, but are also easily comparable with estimates from studies on other developed countries. This accounting method based on quantity indexes has already been approved and is in use by most of the government statistical agencies. Unlike other methods, this quantity index approach does not rely on many assumptions to give correct estimates. This is really important in case of Indian manufacturing, where some of the assumptions required for other methods to work might not hold. For example, the labor input market is non-competitive in Indian manufacturing because labor laws restrict the ability of a firm to fire its worker. As a robustness check, the paper also calculates the growth estimates using other commonly used methods. The paper finds that period-wise growth and productivity improvement trends remain similar, irrespective of the estimation technique used.

The paper finds that registered manufacturing in India experienced growth of gross output at an annual average of 6% between 1970 and 2003 and during the same time net value added grew at an average of 4.2% per year. 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 more insights, with output measures growing at a steady rate until after the reforms. For the period of 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 the 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%). Therefore 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. The average growth rate for materials productivity is negative, indicating that other factors such as labor were being utilized in a way that lowered the output per unit of material used.[15] The labor cost to value added ratio has fallen from 0.6 in 1971 to around 0.3 in 1999. [16]

Using panel data for 58 industries, the paper compares the estimates using same deflator and sector-specific deflators. The differences are very significant, 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 of India publishes the price indexes for most of the industries and this paper uses those specific

[15] The trends in single factor measures depend crucially on what the trends in the other inputs are. In case of Indian manufacturing, these single factor productivity trends are important in understanding the effect of policy restrictions.

[16] This might seem to indicate that Indian manufacturing is becoming very capital intensive. But this drop is being driven by the prices and availabilities of labor and capital. The labor is very cheap in India compared to OECD countries. The ratio has fallen because the capital input has gone up after capital market reforms in 1990s, while labor input has not grown proportionally. Another valid argument is that the labor input is significantly lower because firms are hiring them as contract workers. The ASI has data on expenditure on "services" which includes such payments. The paper subtracts these services expenditure from the gross output when estimating the net value added. Thus the exclusion of contract workers from the L calculation can be justified if we think of these contract workers as equivalent of "outsourcing" in developed countries. Even though their output is part of the production process and hence the value-added, they are not included as labor input. Their output is accounted for via intermediate services. That is exactly what the paper does in its estimation methods.

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) [58] and Olley and Pakes (1996) [63] 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. In net-value-added production function, capital share is around 0.4 while labor share is 0.45 when using Levinshon and Petrin estimation. Olley and Pakes method gives a slightly higher share of labor (0.54). The paper also applies these estimation techniques to period-wise subsamples. The results show that capital share is really low in 1970s and increases in later time periods. Estimates for gross output production function indicate that materials or intermediate inputs are the most important factor. The material share is estimated to be around 60% for Indian manufacturing and it is similar in all sub-periods.

The paper also compares productivity and its growth rates across organization types and ownership types. The structure and characteristics of the firm (decision making unit) should have a profound effect on the production process and its efficiency. Bartelsman and Doms [11] argue that evolution of productivity growth depends on ownership and management. This paper finds that TFP growth and non-parametric technical efficiency improvement are highest in public corporations and local government owned firms. This seems surprising at first, but the efficiency movement plots show that these public corporations and local government owned firms were relatively very inefficient to begin with. After reforms, these public corporations become as efficient as partnership, private limited and privately owned firms. 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 1990s. Higher TFP growth rates of public corporations may be measuring this improvement in average quality of firms due to the sale of the sick units. The paper also studies 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.

The paper calculates 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 [29]. Estimates show that none of the industries are always better or always worse in performance relative to the others. The distribution of improvements in relative performance (i.e. TFP growth rate) does not differ much between 1970s and 2000s. These results go against the explanation that only some of the industries performed well while others did not. The lack of productivity growth was a sector-wide problem.

This paper applies the aggregation techniques such as Domar weights and Fisher quantity indexes to Indian manufacturing data that are common in productivity analysis literature of developed countries. It also studies whether there are any gains from reallocation due to factor movements or due to demand shift between industries. The demand (as measured by output share) increased for the industries with higher TFP growth. But the paper finds that the movement of capital and labor towards more productive industries was restricted, which might have hampered the aggregate productivity growth. Much talked about labor inflexibilities and industrial licensing policy can explain this. Aggregated TFP growth for the entire period is estimated to be around 1.9%. Period-wise trends again show an upward transition around mid-1990s, highlighting the positive impact of reforms.

In following sections, the paper gives a brief description of data and compares different methodologies. The rest of the paper then discusses the estimation results in detail. The results are organized in four sections: all-industries, panel analysis, growth distribution and aggregation.

2.2 Data Construction Issues

The paper uses data based on Annual Survey of Industries (ASI) to calculate productivity and TFP growth rates by various methodologies. The Annual Survey of Industries is the principal source of industrial statistics in India. The survey is conducted annually and provides data on various vital aspects of the registered factories such as number of factories, employment, wages, invested capital, capital formation, input, output, depreciation and value added etc. 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 created from these surveys has 31 principal characteristics for the years from 1973 to 2003. The paper uses both aggregate level data and industry level data for 58 industries based on 3-digit national industry classification (NIC) code.

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

Some other details about ASI dataset and assumptions required to construct different series are mentioned in Appendix B.

2.2.1 Output and Labor

For each of the 58 industries based on NIC code, the survey reports data on gross output. The paper deflates this output by industry specific price indexes, which are available from Central Statistical Organization. In cases where the price data is not available for a particular industry, the paper uses the price series which is closest to the output of that industry. These mappings are mentioned in Appendix B.

The other measure of output is the net value added series. This is obtained using $[(Value\ of\ Output - Total\ Value\ of\ Input) - Depreciation]$.

The ASI dataset has depreciation data for each year and for each industry. Even though this net value added series is provided in the ASI dataset, we still need to create a real net value added (i.e. constant price) series.

ASI has 2 types of data on labor: workers and employees. Employees include workers plus the administrative staff (sales, accounting and other support services) on the payroll. Labor cost data is reported as wages (paid to workers), total emoluments (paid to all employees) and provident fund plus benefits. The paper uses the workers series as labor input [17]. Wage rate is calculated using $[\frac{Total\ WagesPaid}{Number\ of\ Workers}]$. The paper also calculates "extended wage rate" (or total price of labor) that includes the benefits paid/ other costs to the employer. This is estimated by adding average benefits per person i.e. $[\frac{Total\ Benefits}{Number\ of\ Employees}]$ to the calculated wage rate.

Labor quality is another issue that needs some explanation. There is data for India on the overall indicator of human capital (average year of schooling, number of graduates etc.). But the paper does not use a human-capital-augmented labor series, because there is no data on the schooling level of workers in Indian manufacturing. Given that education levels of the Indian population vary a lot, it would be incorrect to assume that growth in education indicators of India as a country can be used as the quality change

[17] The support staff is not included in the labor input. Because even though sales, marketing and accounting are important activities for any firm's operation, these workers do not contribute directly to the actual production process.

indicator for labor in the manufacturing sector.[18] The method discussed in the paper already uses wages for weighting the labor when creating the input quantity index. If the wages are based on "observable" labor quality, then a more educated worker is already weighted higher than a less educated worker.

Labor input is better measured as hours worked rather than number of workers. The ASI dataset does not have data on number on hours worked for each industry for the duration of the study. It has data on "number of mandays" for these 58 industries but only for the years 1979 to 1996. The paper checks the ratio of $(\frac{No\,of\,Mandays}{No\,of\,Workers})$ and finds that even though there are some differences between industries, overall variance within the industry and between the industry in not very large. One outlier is the agricultural products industry (139 days for the year 1979 compared to overall average of 280 days). Extrapolating this data for the whole study period is a tricky exercise. The paper also generates an alternate labor series (measured as mandays) by assuming a linear trend and extending the data in both directions. The purpose is to check the sensitivity of the estimates against variations in labor usage. But most of the productivity results are reported in *per-worker* terms rather than per-manday. This is done to avoid corrupting an already sensitive estimation procedure with assumptions about the trends in working hours.

2.2.2 Materials and Intermediate Inputs

To convert the nominal net value added series into real net value added series, the paper uses double deflation method.

$$VA^{DD} = \frac{Gross\ Output}{Output\ Prices} - \frac{Materials\ Input}{Materials\ Prices} - \frac{Fuels\ Expenditure}{Fuel\ Prices} - \frac{Intermediate\ Services}{CPI}$$

$$NVA^{DD} = VA^{DD} - \frac{Depreciation}{Capital\ Good\ Prices}$$

The paper calculates the growth estimates using single deflation method and compares them with the (more accurate) ones using double deflation method. Balakrishnan and Pushpangadan (1994) [5] show that there are differences in estimated productivity using the single-deflation and the double-deflation methods. The use of single-deflation is declining, because net-value-added is not an actual quantity but an accounting variable. We should calculate it as precisely as we can and hence perform the whole accounting exercise again in real (constant prices) terms, to obtain the real net value added.

[18] There are no other obvious proxies for labor quality in the manufacturing sector (for example service sector employs most of the university graduates, hence one can use that series as quality of labor in the service sector).

Many of the previous studies are not concerned with depreciation, which is wrong as we cannot consume it and hence it should be subtracted from the value added. Just as with intermediate inputs or materials, we can think of depreciation as the portion of the capital that is *consumed* during the production process. Hence, for the precise estimation of net value added we should subtract it.

The tricky part of this double deflation method is which raw materials prices to use. Different industries use different materials. Price trends in these specific intermediate inputs might be very different. Unfortunately, there is not enough data available to create an *industry-materials* mapping which identifies primary materials used for each of the 58 industries (e.g. Leather for shoe manufacturing and crude-oil for refineries). Price series for different raw materials are also not available. Another major issue is that many of the raw materials are imported and producers pay import duties (especially before the industrial policy reforms of 1990s). The paper assumes that wholesale price index of manufacturing materials is indicative of the changes in the price levels of different raw materials being used in various industries.[19] Since the wholesale price index is calculated using domestic data (based on survey of producers), it should include the effect of import duties.

2.2.3 Capital Stock and Flow of Capital Services

One of the most controversial parts of any productivity accounting exercise is the estimation of capital input. Luckily, the main dataset for this paper is constructed using the annual industrial survey. The survey asks firms to report their capital stock under various headings such as fixed capital, physical working capital and working capital along with depreciation, outstanding loans, interest paid, net and gross fixed capital formation and gross capital formation.

The estimation of capital input for the purpose of productivity accounting involves two tasks. The first is to create a series on capital stock (held by a firm, a particular industry or the whole manufacturing sector) and its price. But the second task, which involves dealing with a problem that is unique to the capital input, does not get enough attention in the literature.

[19] An alternative method without making this assumption would be to use the input-output transaction table and construct an aggregate (and ideally for each industry as well) basket of raw materials being used in Indian manufacturing. Then construct a price index of materials prices using the corresponding basket as weights in each year. But data limitations restrict us from applying this *ideal methodology.*

Unlike materials and labor, the capital input purchased in this period is used for the production process in corresponding periods as well. The durability of capital goods makes the accounting process different between renting the capital asset and owning it. We should generate a series for *flow of capital services*. *Capital stock* series and *capital services flow* series are related. In general, the stock value should be equal to the sum of discounted future service flows. OECD manual on measuring capital [67] describes these concepts from an empirical perspective.

Another component in the construction of the capital input series is estimating the consumption of fixed capital (depreciation). The ASI dataset has both depreciation and capital stock data for each industry based on survey responses. Gross capital stock series is acceptable, because its construction is based on what the OECD manual refers to as "*balance of fixed assets*" method. Firms are required to keep a running inventory of their fixed capital assets, tracking outflows as well as inflows. From these reported calculations, the statistical agency can obtain the total capital stock by simple addition. In fact, this method can be seen as a form of the *Perpetual Inventory Method* and it has an advantage because it substitutes actual retirements for the assumed retirements used in the conventional PIM. There is a concern when using the reported net capital stock series, which is derived from gross capital stock by deducting the consumption of fixed capital or depreciation from it. When firms estimate their depreciation numbers, they might not use the correct prices (often using the historic prices) or they might purposefully select a depreciation method or number that minimizes their tax liabilities. That is why it is wise to check the reported values. The paper performs this exercise.

The flow of capital services is derived by calculating the user costs of capital (or price of capital services). The paper uses the following expression

$$Price_{Capital\ Services} = (R + \delta) * Price_{New\ Asset} \tag{2.1}$$

where R is the cost of borrowing and δ is the depreciation rate.

One could use some reasonable values for R and δ to get the price of capital services series from the available wholesale price of capital goods and machinery series. Using central bank lending rate as R and a depreciation rate of around 10% is quite common in the literature.

The paper calculates the implied depreciation rate which is $(\frac{Depreciation}{Fixed\ Capital})$. These rates are different between industries, but for the whole manufacturing sector the depreciation rate varies between 6% and 9.5% during the period of this study. The movement of δ and its variance over time is shown in Figure 2.3. The interest rates in India vary between 9% (in early 70s) and 18% (the currency crisis of 1991).

To be thorough and, more importantly, to find out the differences in rate of return between industries and its movement over time, the paper estimates the "balancing" real rate of return on capital which is the rate of return that makes the profit of firms equal to zero.

$$R_{Balancing} = (Net\ Value\ Added - Labor\ Cost)/Capital \qquad (2.2)$$

The series used in the above expression are in volume terms (current prices).

There is another alternative for creating the capital stock series and that is to generate it using the investment data. We can create the net capital stock series using the perpetual inventory method and assuming a geometric depreciation model. The initial capital stock (K_0) and a depreciation rate (δ) need to be assumed as well. One can test the validity of these assumed values by checking whether the resulting series make sense (e.g. by estimating "internal" rate of return, capital output or capital net-value-added ratio.). This process can be repeated by assuming a different K_0 and a different δ and then checking the resulting series again.

The paper creates the capital stock series and runs few iterations with different K_0s and δs. For estimating the "internal" rate of return, the paper uses total emoluments (which include salary and benefits for support staff as well) as the labor cost. Since the objective here is to calculate the real return on capital, it makes sense to remove all kinds of costs from the net-value-added even if we exclude these support staff and payments made to them when doing the productivity calculations.

Estimated R and $\frac{Capital}{Net-Val-Added}$ using the generated capital series fluctuate a lot. Using the ASI dataset gives similar results: internal rate of return varyies between 17% and 30% and capital net-value-added ratio moves between 1.9 and 2.9. These estimates are plotted in Figures 2.4, 2.3 and 2.1.

Even though the estimated balancing real return rate does not fall after the capital market reforms for aggregate data (Figure 2.1), the median of these rates for 58 industries panel dataset drops significantly after reforms (Figure 2.2). But note that these implicit return rate estimates do not include the capital tax (a reliable series is not available, probably because different industries get different tax treatments in each budget which makes it difficult to create an overall capital tax rate time-series). Hence even if the estimates seem high, it should not necessarily be a cause of concern. Many of the industries are still not fully open to foreign direct investment and capital investment in Indian manufacturing involves fixed costs. Hence we should not expect these to be similar to the return rates in other countries or to the return in the stock markets.

The paper creates this alternate capital series using initial capital value-added-ratio of 2 and depreciation rate of 8%. But since checking whether the generated series give sensible R and $\frac{K}{NVA}$ estimates is a manual process, the paper does not do it. For the disaggregated industrial data using 3-digit NIC code, the paper does not perform any iteration with capital stock and uses the survey dataset series directly. Figures 2.4 and 2.2 show the median, variance and (weighted) mean of R and $\frac{K}{NVA}$ estimates for the industry level panel data.

The paper uses the generated capital stock series to check for the sensitivity of estimates for aggregate data. The productivity estimates and growth are similar to the ones obtained using the ASI dataset capital series. The results are reported for the Annual Survey of Industries capital series.

2.3 How to Account for Output Growth?

Productivity estimation should be a straight forward exercise based on standard methods. But regrettably that is not the case. Agreement on System of National Accounts (1993) [62] and the release of the OECD productivity manual (2001) [38] have not helped in reaching a consensus on which methods and which measures to use for analyzing the productivity growth. This is especially true for studies on Indian manufacturing. In this paper, two measures of output are used: gross output and net value added. In the 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.

One of the most used indicators of productivity growth is Total Factor Productivity. TFP growth tells us how much extra output the manufacturing sector produced compared to the previous year after accounting for the increase in inputs. Put another way, TFP growth rate measures how much the growth in output would have been if the input usage had remained the same. This paper calculates both growth rates for TFP and Single Factor Productivities [20] (including labor productivity growth). Note that these

[20]Even though the SFP growth rates do not necessary estimate the technological progress or efficiency gains, these can still be informative. For example, labor productivity growth rates are commonly used as indicator of productivity gains especially when

two productivity variables are measuring two different economic entities and should be interpreted accordingly. For example, the growth due to increased or better usage of other factors in also included in single productivity numbers (i.e. growth due to increased capital-per-worker).

The other question regarding the productivity estimates is which of the several accounting methodologies to use. The techniques used in the literature are traditional growth accounting, index number method, data envelopment analysis and stochastic frontier method. The paper applies these four methodologies to the Indian manufacturing dataset and discusses the results.

Traditional growth accounting and index number method rely on functional form of the production function. Data envelopment analysis is non-parametric, while stochastic frontier method requires making some assumption about technology trend. Another difference between these two sets of methods is that envelopment analysis and stochastic frontier methods estimate the *efficiency* while growth accounting and index number methods are used for calculating *productivity* estimates.

Even though they are sometimes used interchangeably, efficiency gains and productivity growth are not the same. Efficiencies (technical and allocative) indicate how far away the production process is from the existing production *frontier*. The productivity growth also includes the growth due to the technological progress (i.e. moving of the production frontier itself).

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. We can take care of the changes in factor shares over time, by using the indexes of input and output quantity growths and then estimating TFP growth rates using these indexes. Index number method can also help us with the issue of dependency on the functional form. [21]

The paper finds that the point estimates are different using growth accounting (constant share) and using index numbers. This is because some of the growth, which is due to the changes in factor usages, incorrectly shows

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comparing across sectors or countries. One advantage of using labor productivity estimates is that unlike TFP estimates these do NOT depend on capital stock.

[21] Tornqvist index is exact to the *translog* function, which itself is a flexible functional form and approximates any actual production technology up to the second order. So assumption about production function or accuracy of parameter values is not an issue.

up as TFP growth when doing traditional growth accounting. The paper also compares the period-wise trends and finds that both set of estimates move in similar directions. Indian manufacturing experienced a drop in TFP growth rate in early 1990s, but later TFP growth started to go up.

DEA and stochastic frontier differ in the way the production technology frontier is estimated. Stochastic frontier assumes a functional form for the technology and decomposes the growth into technical efficiency and technology shocks. DEA is used for cross-sectional data and the "envelope" (i.e. frontier) is derived using all the different input allocation bundles and finding the most efficient ones. Despite its non-parametric approach, the choice of model (cost minimization or profit maximization) and assumption about production technology (constant return to scale, convex or quasi-concave) have the potential of making the DEA results inaccurate. DEA is especially useful in cases where price data is not available, since index number methods cannot be applied. But presence of measurement errors affects the accuracy of DEA estimates most severely. [22]

The paper finds that the trends in estimated efficiency gains (obtained using DEA and stochastic frontier method) are similar to the trends in TFP growth. This is encouraging and shows the robustness of the results. The common trend is that the productivity growth in Indian manufacturing slows down and dips, before starting to increase again in mid-1990s.

2.3.1 Productivity vs Efficiency and Earlier Results

As mentioned earlier, even though both the measures (productivity and efficiency) denote the production capabilities of a firm, they are conceptually different. While the productivity measures the output produced by single unit of (combined) input, the efficiency is a *relative* concept and involves estimation of *production frontier*. The production frontier denotes the maximum possible production level for each set of inputs. Firms are *technically efficient* if they are operating on the frontier. A technically efficient firm can still have the scope to improve its productivity by moving to another point on production frontier if it is not operating at *optimal scale*. Between two time periods, the production frontier might move due to *technical change*. If price data is available, the firms can also be evaluated based on their input

[22] The efficiency estimates are obtained using DEA methodology are *relative*. The solution to linear programming problem is derived using the observed input-output data. Hence there is no way to find out what the "*potential*" output could have been, if there were no across-the-board inefficiencies (for example the quantitative restriction faced by Indian manufacturing firms before 1990s).

allocations. The *allocative efficiency* measures the success of a firm in using the optimal proportion of inputs given their prices. These concepts were pioneered by Farrell (1957) [35] and then later expanded in Aigner, Lovell and Schmidt (1977) [4] and in Banker, Charnes and Cooper (1984) [7].

The Malmquist TFP index introduced in Caves, Christensen and Diewert (1982) [22] measures the productivity growth based on the radial distances. If the firm is technically efficient, the measured productivity growth between two periods is only due to the improvements in production technology i.e. a shift in production frontier. But if the firm is technically inefficient, the measured total factor productivity changes are combined effects of the technical efficiency gains and the production technology improvements. This paper estimates the productivity growth, efficiency gains and technical changes for Indian manufacturing firms between 1970 and 2003 using a panel of industries.

There have been a number of studies on estimating the productivity growth in Indian manufacturing. But there is no consensus on the actual productivity growth rates and more crucially on the period-wise trends. The huge discrepancies in the results as shown in Goldar (2002) [42] highlight the problem. The ranges of estimates for average productivity growth rates are -0.3% to 5.5% for the 1970s and -1.2% to 3.4% for the 1980s. There is no agreement on the growth trend either. Ahluwalia (1991) [2] finds that average TFP went down for the organized manufacturing sector between 1965 and 1980, while Goldar (1992) [40] claims that TFP growth average was 1.55% in the 1970s. Most of the studies lack detailed description on how the dataset was constructed, how intermediate inputs/ services were accounted for and which methods were used to obtain the productivity estimates. Instead of responding to criticism by increasing the transparency, the debate has shifted towards single-deflation vs. double-deflation methods and net-value-added vs. gross-output based measures. More recently, many researchers have started concentrating on estimating the effect of various reforms in India on the manufacturing productivity. Balakrishnan, Pushpangadan and Babu (2000) [6] find no evidence of acceleration in productivity growth till 1998 which is similar to what this paper finds. They use the data provided by Centre for Monitoring Indian Economy. But they do not use the methods suggested in OECD manuals on capital and productivity measurements [38] [67], which are standard practice elsewhere and use their own calculations while deriving capital stock series. Das (2004) [28] studies the performance of Indian manufacturing under various trade regime and finds that for a vast majority of industries the TFP growth rates became worse in the 1990s. Goldar (2004) [41] shows that the conflict among researchers is still continuing. He mentions that two studies as recently as 2003 have found that TFP growth in Indian manufacturing accelerated after 1991. His own set of estimates contradicts those findings.

This paper tries to be more transparent by describing the dataset construction in detail and to be more widely acceptable by using the standard sets of measures and methods and by avoiding the unjustified assumptions. Two sets of TFP growth rates along with the measures of efficiency gains are estimated. Index number and traditional growth accounting techniques are used for TFP calculations while efficiencies are calculated using the stochastic frontier and data envelopment analysis techniques. The paper also performs the aggregation over various industries and looks at the long term (smoothed) growth trends. The production function for Indian manufacturing is also estimated using different specifications.

The following sections discuss the results obtained using various methods for Indian manufacturing dataset for the period 1970-2003.

2.4 All Industries: Estimates and Growth Trends

The paper estimates the input (capital, labor and materials) and output growth rates for all industries, i.e. aggregate data. Period-wise averages of annual growth rates in input and output quantities are shown in Table 2.1. As Hulten and Srinivasan (1999) [47] point out, output growth rates are not as bad as many in the literature believe. Average of growth rates between 1970 and 2003 (32 years) is 6% for gross output and 4.2% for value-added. During the same period, labor and capital growth rates have averaged 1.1% and 3.6% respectively. Materials usage has grown by 6.5%, which is even higher than the growth rate of gross output.

Most surprising are the estimates for the last sub-period, 1998-2003. Contrary to the notion, output growth rates in this supposedly more reformed period are lowest (3.2% & 0.6% respectively). The reason for this seemingly dismal performance between 1998 and 2003 is the lack of input growth. Growth rate average for both capital and labor inputs are around -4%. If growth in input accumulation was important for the growth of Asian tigers, 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 cannot keep pace. Another reason might be the creation of Department of Disinvestment to sell off the non-performing public sector units. This reduces the value of capital stock being used in manufacturing and shows up as negative capital growth.

Estimated average growth rates of net-value-added using double deflation method and using Fisher quantity index do not differ by much, with the latter resulting in slightly higher estimates. Using **"incorrect"** single deflation method (one that does not use value-added deflator) *reverses* the trend in growth rates in 1970s and 1980s. Growth rate of net-value-added is higher in 1970s than in 1980s when using double deflation method, but growth estimates become lower in 1970s compared to 1980s if single deflation is used. This might explain the debate that dominated the earlier Indian manufacturing literature.

One of the issues in studying growth over a long period of time is that each year the rate of growth fluctuates. The paper studies growth *trends* by separating fluctuations using HP filter smoothing [23]. This is also helpful in looking for similarities among estimates from different methods. In fact, the paper finds that the smoothed series of the estimates using different methods do show similar trends. We can definitely say that the growth of productivity slowed down in Indian manufacturing and then reforms in 1990s changed that pattern.

Figure 2.5 shows the trends in input and output growth rates. Gross output growth rates showed an upward trend in the early 70s and have gone down in late 90s. Materials usage growth rates increased a lot in the 70s. These are trends in growth rates and hence even a downward trend means that the series is still growing (as long as it is above zero) but at a slower pace. The drop in capital growth rates seems to happen just after reaching a peak in early 1990s. The capital growth rate has gone down ever since. This could be explained by disinvestment initiatives and the *capital base* of the manufacturing sector becoming too large over the years. Labor growth rate has been continuously decreasing, which is not surprising given that most of the states still have inflexible labor laws.

The results of period-wise average growth rates of productivity measures [24] [25] are shown in Tables 2.2 and 2.3. These estimates are for the aggregate

[23] HP filter gives a smoothed non-linear representation of the growth-rate time series, one that is more sensitive to long-term than to short-term fluctuations. HP filter is also good in removing business cycle fluctuations and is a standard practice in macroeconomic studies. Since the ASI dataset is based on yearly survey, the paper uses the value of multiplier λ equal to 100. The paper does sensitivity testing by using moving average and non-linear smoothing techniques. The trends remain similar to the ones obtained using HP filter.

[24] Cobb-Douglas specification with Hicks neutral technical change parameter is assumed for growth accounting. TFP using index number is calculated using $TFP = Y(p^t, p^{t+1}, y^t, y^{t+1}) \ / \ X(w^t, w^{t+1}, x^t, x^{t+1})$, where X is the combined quantity index.

[25] *Shazam* is used for calculating index numbers. *DEAP* program available from the

data, which is referred to as *All-Industries* in the dataset.

On average, labor and capital productivities in terms of gross output (Table 2.2) have 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 despite decreasing input usage. This should be seen as a sign that reforms are working. Even though output growth rates are higher in early 1990s, that growth was mostly due to input accumulation. The period between 1998 and 2003 experienced much better (K,L) productivity growth. The estimates from different methods show a similar pattern between time-periods. [26]

Results for productivity growth estimates using value-added as measure of output are shown in Table 2.3. Between 1971 and 2003, average TFP growth rate using net-value-added is estimated to be 3.4% (growth accounting) and 2.3% (index number). Again, the last sub-period of 1998-2003 shows impressive TFP growth of around 4.8%.

Figure 2.6 shows the trends in these different productivity growth measures. TFP growth was stagnant during 1980s. There definitely is a transition and TFP growth seems to be picking up in early 90s. The trends are similar; irrespective of the measure or the methodology used.

The paper also decomposes the growth of nominal output into growth in netput (net output) price index and growth in input quantity index using methodology of Waren, Fox and Kohli [39] and Diewert and Morrison [30]. The equivalent of a Terms-of-Trade effect is estimated by treating the material input as negative output. Figure 2.7 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 2.4. 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%. But period-wise decomposition varies a lot. For example in the last sub-period (1998-2003), nominal output grows by 8.0% per year despite the input quantity index dropping at a rate of 3.5% per year (i.e. negative 3.5% growth rate). Net-

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Centre for Efficiency and Productivity Analysis is used for efficiency estimation. Input oriented DEA is used and the slacks are calculated using multi-stage method. *Stata* software is used for all other calculations (including stochastic frontier), regressions and plots. Stochastic frontier is based on the Cobb-Douglas production (log form) and half-normal distribution is used for the inefficiency term.

[26] Table 2.2 also includes the estimates of TFP grow rates when material is not included as an input to the production process. These results are shown to shed some light on the range of differences in the estimates found in earlier literature.

put price index and the estimated TFP grow at around 6% per year during this last sub-period.

2.4.1 Effect of Firm Characteristics

The ASI dataset also has data on major classification of factories. For example, data can be categorized by type of organization or type of ownership, by size of employment, by state, etc. Most of the previous studies on Indian manufacturing discuss the differences in growth rates across different states. Goldar and Veeramani (2008) [26] 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. The approach is based on the argument that productivity is affected by the management practices, which are determined by its organization and ownership type. In fact, these factors affect a firm's productivity probably more directly than its geographical location. Goldar, Banga, Renganthan (2003) [16] find significant differences in technical efficiency between private sector and public sector engineering firms.

The paper estimates the TFP growth rates by organization types and by ownership types. Period-wise averages of TFP growth rates are shown in Table 2.11. The results show that there are significant differences in productivity (TFP) growth rates among various types of manufacturing firms in India. Average of TFP growth rates for public corporations is 7.4% and for the sub-period of 1998-2003, this average is an astounding 17.8%. Similarly, local government-owned manufacturing units experienced average TFP growth of 7.2%.

This is an interesting finding and at first glance it might seem counter-intuitive. But, most of this TFP growth in public sector happened after the reforms, while private manufacturing firms did not experience this huge jump in TFP growth due to reforms. We have to keep in mind that these are TFP growth rates and not the productivity level. If the productivity levels of the government firms were very low 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 probably catching up with private manufacturing firms in terms of productivity.

To check out the efficiency improvements across various types of firms, the paper applies the stochastic frontier method. The paper calculates the technical efficiencies for both categories, organization types and ownership types. These efficiencies are plotted in Figure 2.12 (by organization types) and in Figure 2.13 (by ownership types). These figures show that efficiency gains are higher in the public sector. Private sector's gains are comparatively smaller, but private sector firms were already a lot more efficient than the public sector firms.

To compare the growth in efficiencies (technical and scale) and productivity from 1970 to 2003 for various types, the paper also calculates the "Malmquist Index". The results (geometric mean over these 33 years) by the organization types are shown in Table 2.12. Average productivity growth rate for public corporation is higher than the average for private limited firms.

Another criticism of earlier Indian industrial policy is that it focused too much on promoting small-scale industries. These small firms were responsible for slowing down the performance of Indian manufacturing. To check for this, the paper estimates the TFP growth rate by firm size in terms of number of workers. Period-wise distribution of TFP growth over the number of workers is shown in Figure 2.11. There does not seem to be any regular pattern in the distribution. For the entire period (1974-2003), TFP growth average is slightly higher (around 3.8%) for medium sized firms (50-99 and 200-499) compared to the average of around 2.9% for other sizes. Small sized firms (0-4 workers) registered an average TFP growth of just 1.8%, which is a lot lower than others. Hence the criticism of very small-scale industries seems to be justified.

2.5 Panel Data Analysis

In this section, the paper uses the panel dataset based on 3-digit industry groups based on National Industrial Classification (NIC) code for the years 1973 to 2003. The 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 the quantity series (real gross-output and real net-value-added). There is a lot of debate in literature about choosing the right deflator. To find out whether this accuracy matters, the paper also calculates output, net-value-added and TFP growth rates using the same deflator for all the industries and then compares the period-wise averages with the ones estimated using industry specific deflators. The results are shown in Table 2.5. Even though one set of estimates is not always greater than the other, for the entire period (1973-2003) the estimated average growth rates [27] are higher when using sector-specific deflators. But this is not true for all the sub-periods and there is no reason to assume that a systematic relation (higher or lower) between these two sets of estimates exists. Since sector-specific price indexes are readily available now, these should be used rather than using a common deflator.

Using the quantity (real) series, the paper estimates two production functions: gross-output with labor, capital and materials as inputs; and net-value-added aggregate with only labor and capital as inputs. The paper uses Cobb-Douglas, CES and Translog functional forms. The results are shown in Table 2.6. As expected, estimated factor shares vary a lot depending on the specification. But in all the specifications, material share is the most significant one in gross output production. This highlights that intermediate inputs are important for Indian manufacturing and should be included in productivity accounting. Tables 2.7 and 2.8 show the estimation results for CES and Translog production function. As mentioned earlier, CES function with gross output and only two inputs does not make sense. Results of these hypothetical elasticities are reported just for the reference. For value-added CES specification, estimated ρ is -0.9. This value points towards capital and labor being strong substitutes. Translog function gives a similar result regarding the factor share. Material is the most important of the inputs and its share is close to 0.5.

2.5.1 Production Function Issues

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 are related to the input choices. Levinshon and Petrin [58] solve this issue by suggesting a two step process using intermediate inputs as control for observed technological shocks. Olley and Pakes [63] suggest another similar method which deals with additional selection bias using investment as proxy. [28]

The paper uses *Stata* implementation of Levinshon-Petrin and Olley-Pakes methods. Results are shown in Table 2.9. It turns out that two of the trends we got from the other methods are verified by these methods as

[27] Calculated as unweighted average of all the industries.

[28] The capabilities of these two methods in solving the simultaneity bias is doubtful, because these are still based on single equation model and rely on a functional form.

well. The labor share is changing and it starts to godown after 1990s. The share of materials in gross output is very high (around 0.6).

The paper also estimates the stochastic frontier production model using Stata *xtfrontier* command. Both time-invariant technical inefficiency and time-varying decay models are estimated. To check for structural breaks, the paper applies the estimation procedures on period-wise subsamples. Results of these estimations are shown in Table 2.10.

Estimates show that the importance of capital in value-added (as indicated by its estimated share in production) has been growing over time, with the share becoming around 0.6 in the last period of 1998-2003. Labor share is going down, which should cause some serious concern. Despite its huge success in the service sector, India has a large pool of unskilled labor. This jobless growth (share of labor going down) will become a serious problem if Indian government does not address the issue of pro-worker labor laws. The result of significance of materials in gross-output production appears again (the share being close to 0.5).

2.6 TFP Growth Distribution and Productivity Transition

This section deals with the TFP growth performance comparison using the panel dataset for 58 industries over 30 years. The paper studies the distribution of TFP growth among industries because many of the government policies were industry-specific and to find out how productivity has improved over time in different industries.

The paper calculates the TFP growth rates for each industry group using real quantity series. 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" registering on average a TFP growth of -1.8% per year[29]. Yearly distribution of TFP growth rates is shown in Figure 2.8. We can see that there are some overall good years (e.g. 1974, 1994) and some overall bad years (1982, 1993), but the distribution of productivity growth across industries does not have any clear pattern over time.

The scatter plots of start year and end year TFP growth rates for each of the sub-periods are shown in Figure 2.9. In Figure 2.10 pre-90s and post-90s TFP growth rate averages are plotted. This is done to find out whether there

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

are any consistently good and consistently bad industries (in terms of TFP growth performance). Just like yearly distribution, period-wise industry performance also varies a lot. For example the 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 notice that these are the industries which focus more on providing services rather than producing or manufacturing goods using raw materials.

To find out how industrial TFP growth has evolved over time, the paper uses Bartelsman and Dhrymes (1998) [29] technique of productivity transition matrix. The paper compares the performance across time and over the industries.

For each year, industries are ranked from 1 to 10 based on their TFP growth rates.

$$(TFPGDecile)^i = [TFPG^i - TFPG^{min}].div.[\frac{TFPG^{max} - TFPG^{min}}{10}] \tag{2.3}$$

These period-wise ranks (TFP Growth Decile) show that the relative growth performances are very much random. There are no consistent leader industries and no consistent laggard industries. This seems contrary to the popular notion that some industries always performed worse than the others.

To compare the performance between time-periods, the paper studies the *productivity transition* which is the probability distribution of industries moving to a higher or a lower TFP growth decile compared to the last period. This distribution of improvement in relative rankings is indicative of productivity performance of that time period. In theory, it is possible to have a distribution skewed towards the right if most industries register close to the maximum TFP growth (frontier) and hence improve their ranks/ deciles. These transition plots for the beginning and end of the study period (i.e. 1970s and 2000s) are shown in Figure 2.14. The paper plots one, two and three year transitions. Even though the distributions are not exactly similar for 1970s and 2000s, there are not many remarkable differences. The paper also checks the productivity transitions for other time periods, but finds that the growth performance has been quite random across industries and not much different between the periods.

The results in this section go against the claim that there were no sector wide inefficiencies and that only few badly performing industries were responsible for the poor productivity growth rates in Indian manufacturing.

This clearly was not the case. Even though services-oriented industries (ones with higher NIC codes) performed much better compared to others, there is no clear trend in the relative growth performance of different industries over the years.

2.7 Aggregation and Reallocation

One of the mechanisms through which productivity improves is the factor reallocation. Capital moves to more productive industries to get higher returns. Labor also moves to the industries that pay higher wages (which are the ones with higher labor productivity). When we aggregate over all industries, these movements show up as productivity gains compared to the previous period.

The paper checks whether labor and capital moved from less productive industries to more productive industries. In Table 2.13, the paper calculates 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 base period (1974) shares. This is not a decomposition, but it can tell us whether the "actual" shares are better than the "initial" shares when it comes to TFP growth rates. Similar comparison for labor productivity growth and capital productivity growth are also performed.

The results show that for capital-share-weighted and labor-share-weighted TFP growth rates, averages are lower when using actual shares compared to the averages when using 1974 shares. It means that overall the labor and the capital did not move into the industries that experienced higher TFP and productivity growth. One explanation is the presence of distortions in Indian manufacturing. In an ideal scenario, industries with lower productivity growth should cut back their operations, possibly by decreasing the number of workers and thus increasing the labor share of other more productive industries. But since existing labor laws in most of the states prohibit such a reduction, this does not happen in Indian manufacturing. We can say that the presence of the labor market distortions (labor not moving to the most productive industries) hampered the aggregate productivity growth. Similarly, the inability of capital to move towards the industries with higher TFP growth can be attributed to the licensing restrictions that were part of the industrial policy before the reforms. Output share weighted TFP comparison shows expected trends. There are gains from reallocation due to demand shifts between industries. These gains in average TFP growth rate over the entire time period are 30%. This straight-forward comparison shows that labor and capital did not move to the industries with higher growth rates, despite a shift in demand towards those industries.

To find the estimates of aggregated TFP growth rates for 58 industries panel, the paper uses both the index numbers and Domar weights techniques. Fisher quantity index for output (and corresponding growth rate) is calculated by combining individual outputs and industry-specific prices into a single quantity aggregate. Labor and capital for different industries are treated as different inputs. These are aggregated using industry-specific wages and industry-specific "balancing" rate of returns as prices. TFP growth is then calculated as the ratio of input and output quantity indexes. Domar [32] showed how inter-linkage between industries can lead to aggregate productivity growth being larger than the simple weighted sum of individual productivity growth rates. This is especially true in the manufacturing sector where output of one industry acts as intermediate input for another industry. Using Bartlesman & Beaulieu (2004) [10], the paper calculates Domar weight for each industry using the following expression:

$$D_i = \frac{(GO)^i}{(GO)^{ALL}} * [\frac{Net}{Gross}]^i * [\frac{Net}{Gross}]^{ALL} \tag{2.4}$$

Period-wise averages of aggregate growth rates using these two methods are shown in Table 2.14. The aggregated output growth rate averages around 6.6% and aggregated input growth rate average is 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. The average 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 2.15 and 2.16. The change in the directions of growth trends of these aggregated TFP measures is very clear. TFP growth slows down and then starts going up again. This transition is occurring in mid-90s, which is a sign that the reforms were responsible for this turn around.

These trends are consistent with the growth trends obtained earlier using all-industries data. Hence this exercise is successful in reaffirming that productivity rates in Indian manufacturing went down between 80s and 90s before starting to increase again in late 90s.

The paper also documents the Domar weights and the estimated period-wise TFP growth rates for each industry in table 2.15. These results can be used for comparison between various industries.

2.8 Conclusions

The paper analyzes the growth experience of the 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, when available, in calculation of growth estimates. Intermediate inputs or materials are a very significant factor in gross output production function for Indian manufacturing. 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, probably due to inflexible labor laws. TFP growth rates of public corporations and local government owned firms are larger, but these were more inefficient to begin with. TFP growth rate is independent of firm size, except for very small firms.

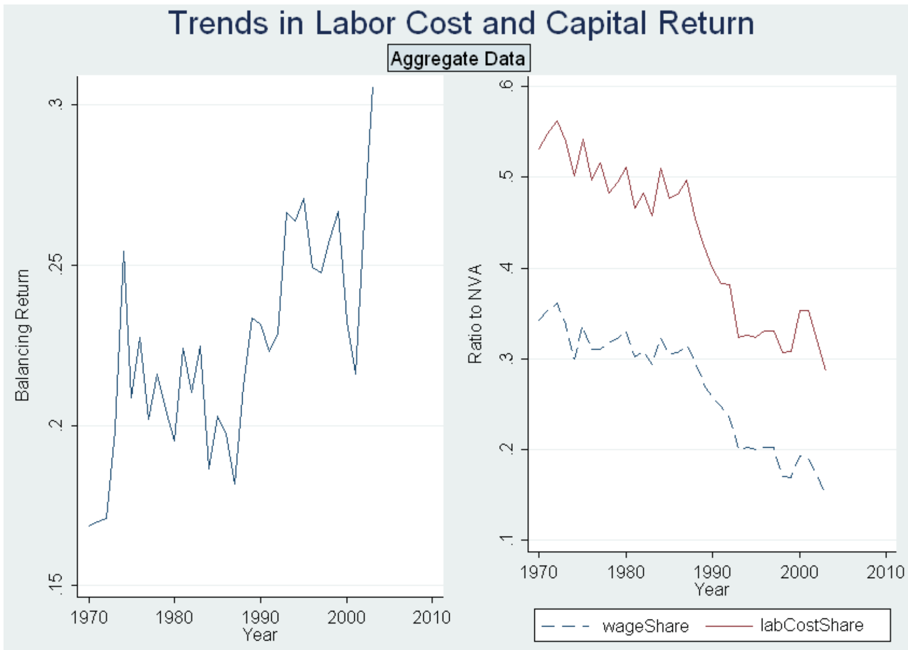


Figure 2.1: Labor Cost Share and Capital Return - Aggregate

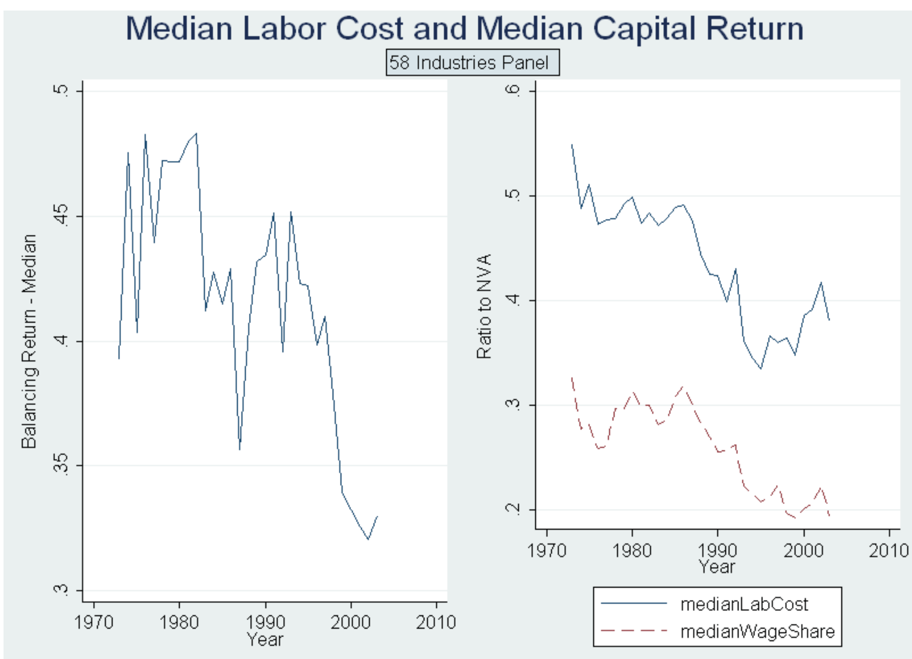


Figure 2.2: Labor Cost Share and Capital Return - Panel (Median)

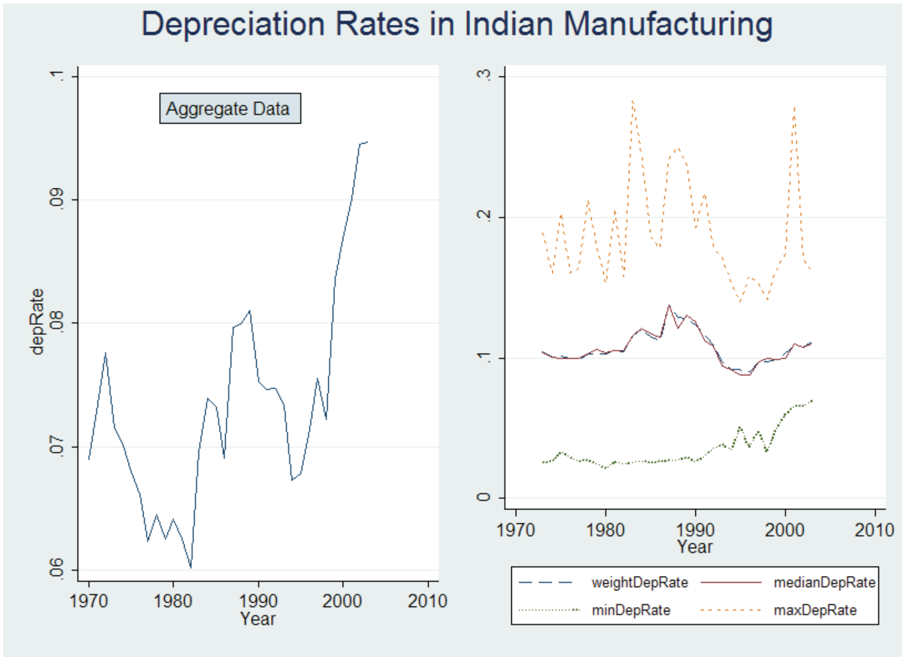


Figure 2.3: Reported Depreciation Rates - Aggregate & Panel

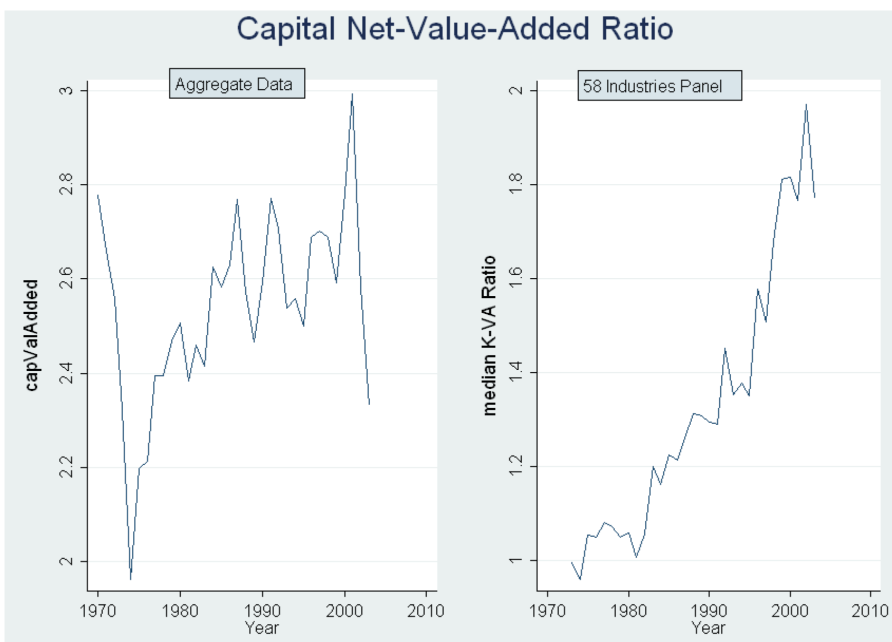
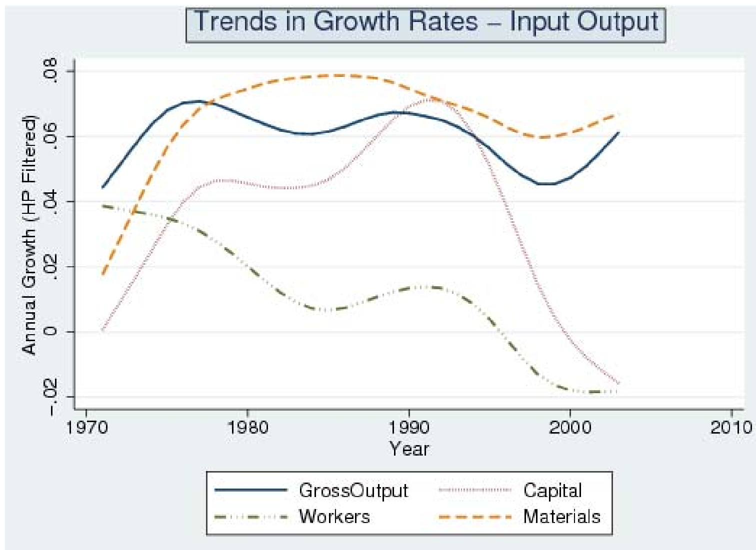


Figure 2.4: Capital to Net Value Added Ratio - Aggregate & Panel (Median)



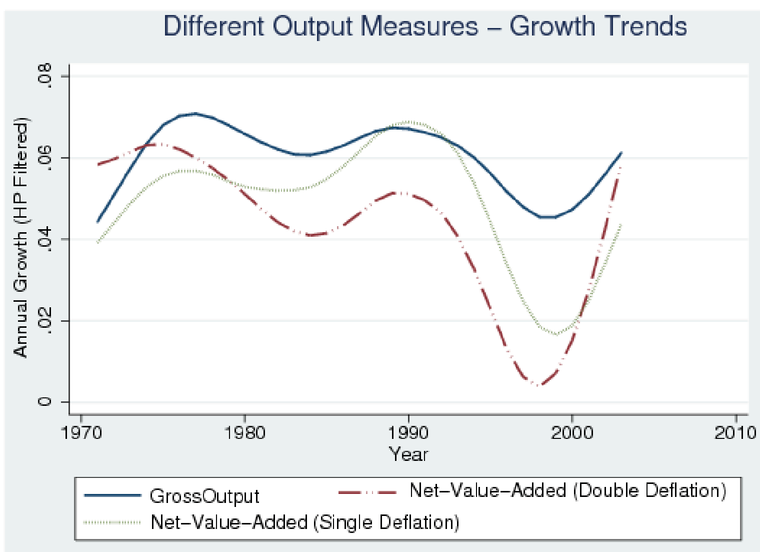


Figure 2.5: Input and Output Growth Rates - All Industries

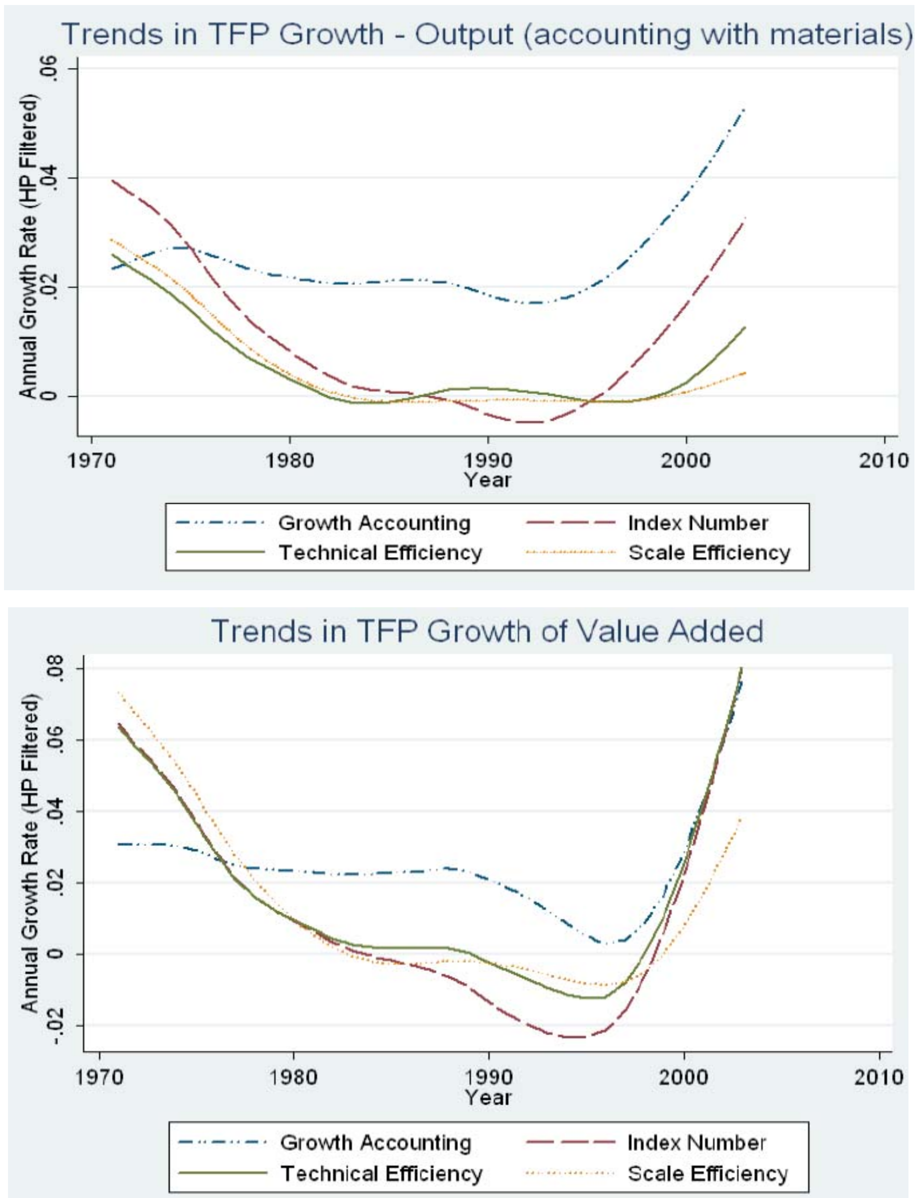


Figure 2.6: Productivity Growth Trends - All Industries

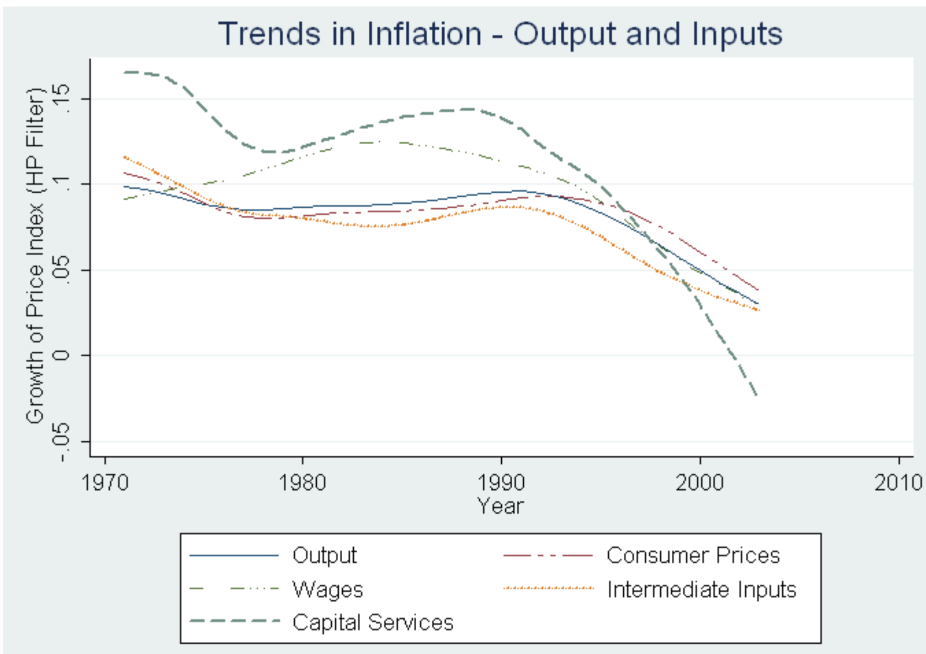


Figure 2.7: Trends in Input and Output Inflation

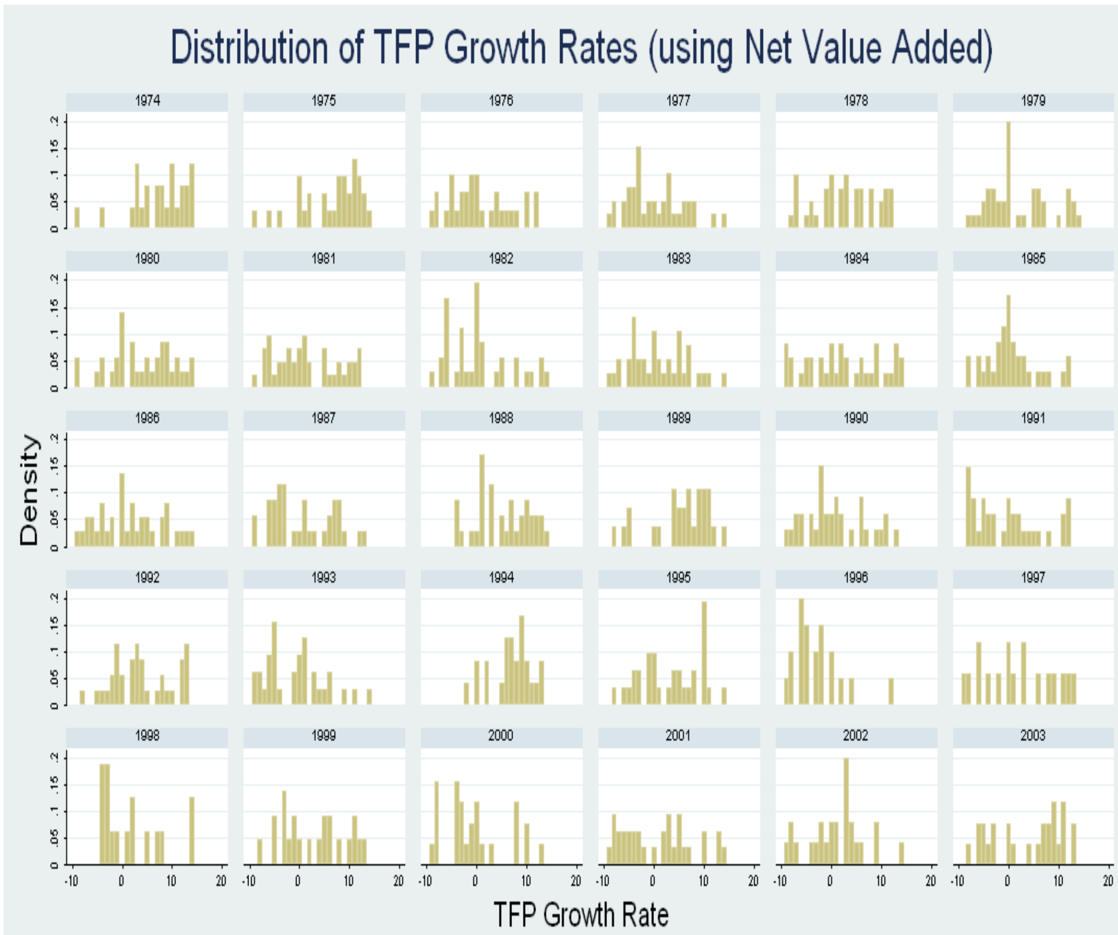


Figure 2.8: Distribution of TFP Growth Rates over Time

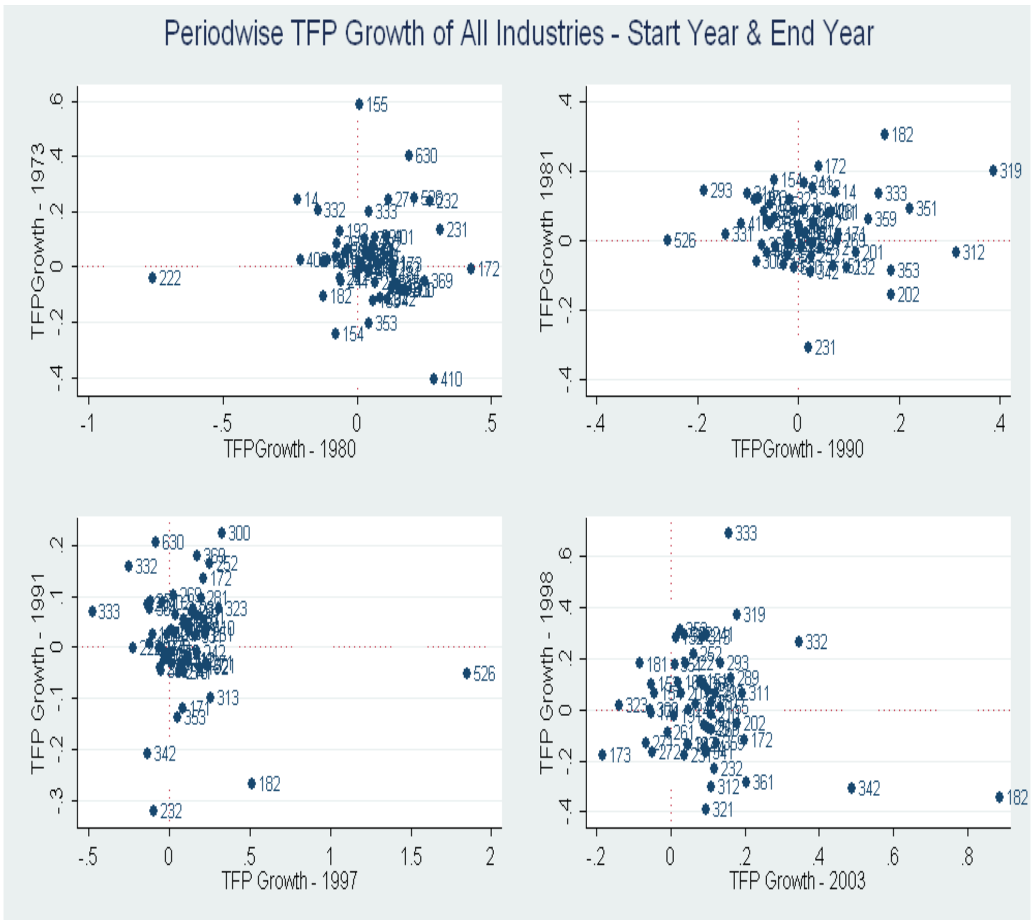


Figure 2.9: Period-wise TFP Growth Rate Comparison - by Industries

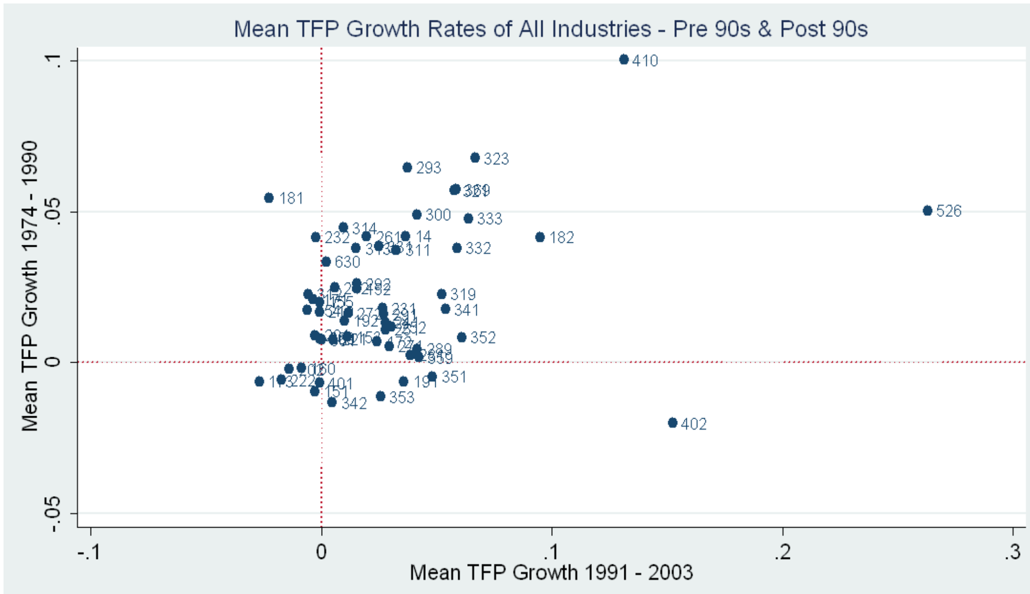


Figure 2.10: Pre and Post 90s TFP Growth Rate Comparison -by Industries

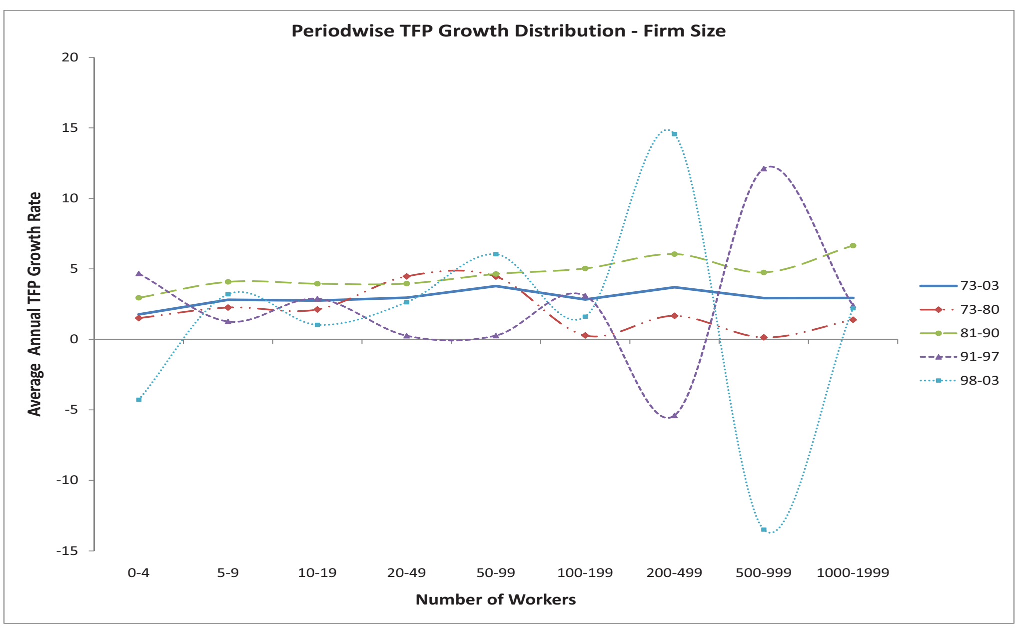


Figure 2.11: Periodwise Distribution of TFP Growth - by Employment Size

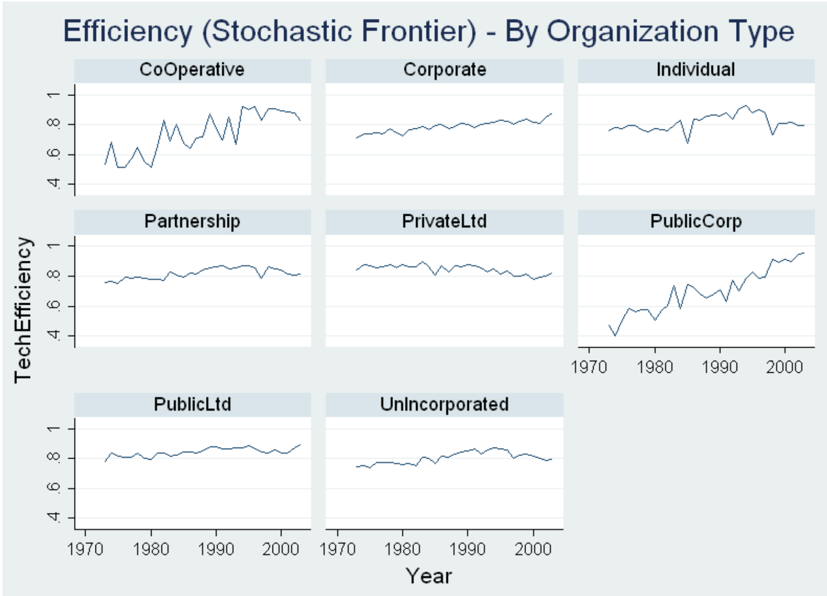


Figure 2.12: Efficiency Movements - by Organization Types

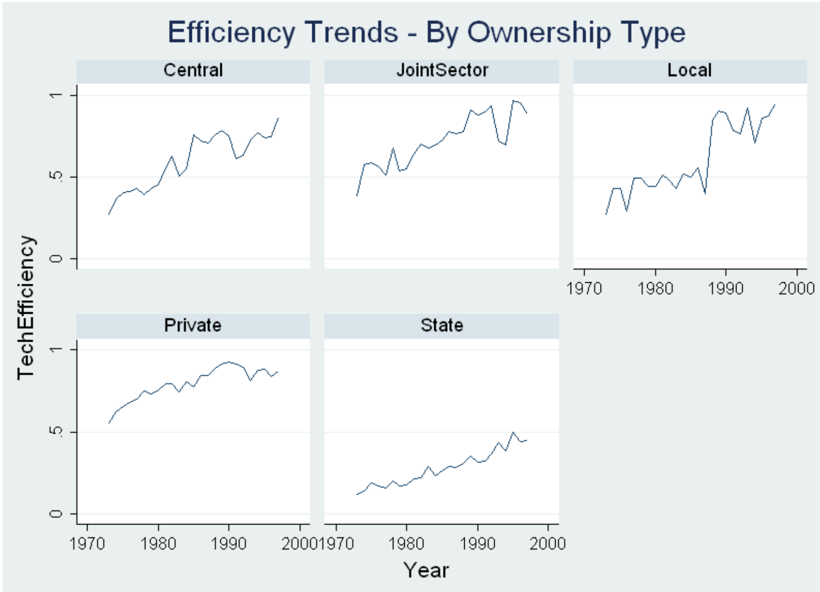


Figure 2.13: Efficiency (Stochastic Frontier)- by Type of Ownership

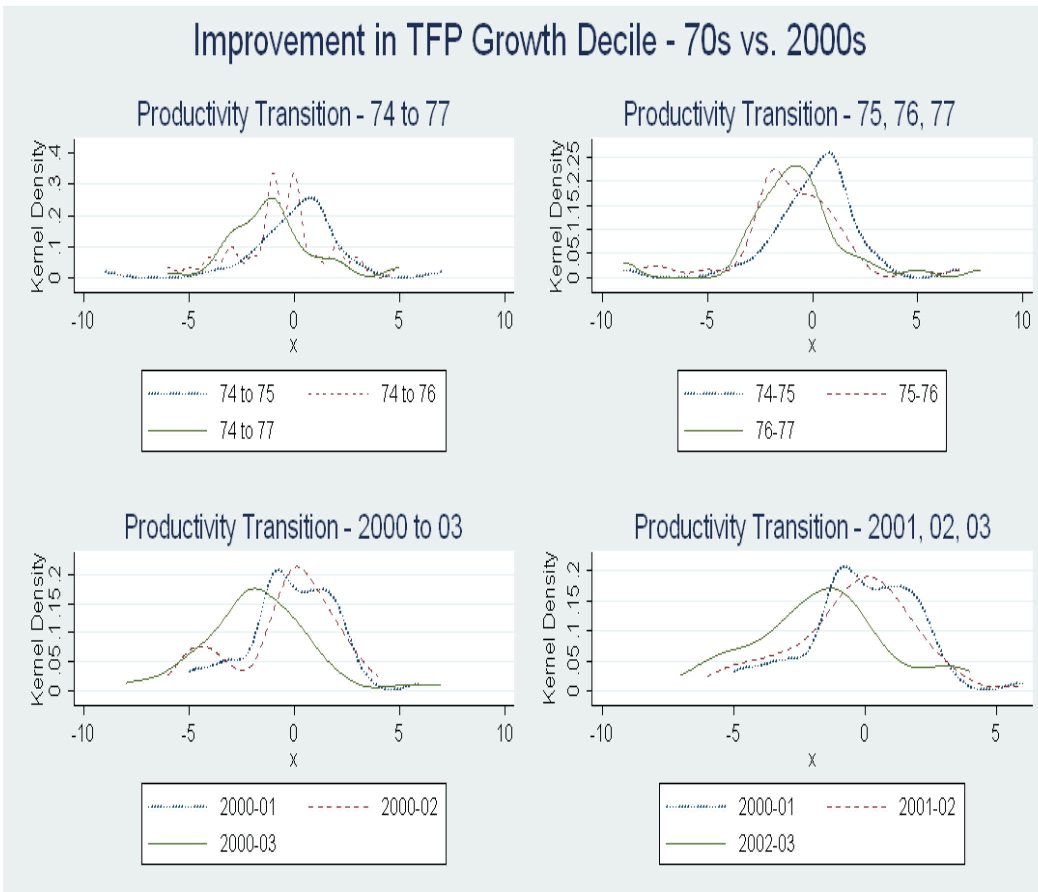


Figure 2.14: Productivity Improvement - 70s vs. 2000s

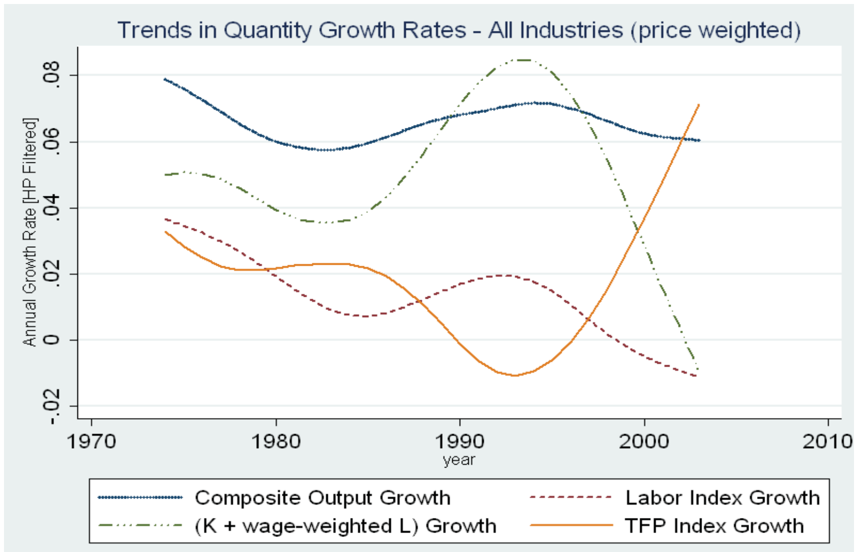


Figure 2.15: Aggregated Quantities and TFP - Growth Trends

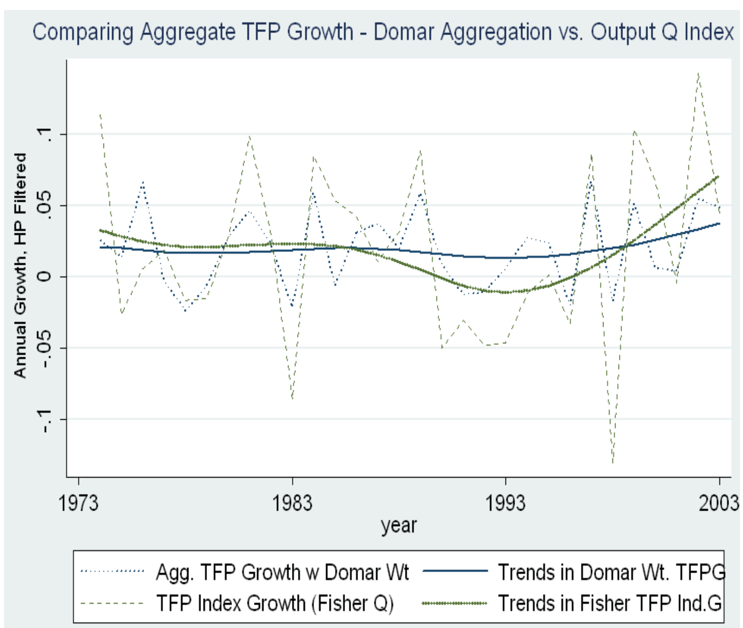


Figure 2.16: TFPG Aggregation over All Industries - Domar Weights vs. Fisher Index

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%
Net-Value-Added(Fisher)	4.4%	6.5%	4.1%	4.7%	0.9%
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	5.0%	6.6%	8.5%	3.9%	-2.1%

Table 2.1: 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}	**2.5%**	**2.4%**	**2.5%**	**1.3%**	**4.2%**
	[4.1%]	[2.8%]	[5.1%]	[2.5%]	[6.9%]
TFP ^{Index}	**1.3%**	**2.4%**	**2.2%**	**-0.8%**	**2.8%**
	[2.7%]	[2.9%]	[2.6%	[-1.5%]	[7.4%]
Tech Efficiency ^{CRS}	**1.2%**	**2.1%**	**2.8%**	**0.2%**	**1.9%**
	[2.7%]	[3.0%]	[2.5%]	[-1.4%]	[7.2%]
Scale Efficiency	**1.1%**	**1.7%**	**1.1%**	**0.1%**	**1.5%**
	[2.5%]	[4.6%]	[2.0%]	[0.2%]	[3.8%]

[a] []: Square brackets are the (inaccurate) estimates, when material is not accounted for as input.

[b] Tornqvist and Fisher indexes give similar results. Tornqvist values shown.

Table 2.2: Productivity Growth Rates - All Industries

Annual Growth Rate (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^{GrowthAccounting}	3.4%	4.1%	3.4%	1.1%	6.3%
TFP$^{Index-Tornqvist}$	2.3%	4.6%	4.2%	- 2.2%	4.8%
Tech Efficiency^{CRS}	2.1%	4.4%	3.7%	-1.9%	5.6%
Scale Efficiency	1.3%	4.2%	-0.2%	-0.1%	3%

Table 2.3: 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[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 Divisia and Fisher are exactly the same.

Table 2.4: 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 2.5: 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 2.6: 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
$Y = NVA, X1 = K, X2 = L$	0.35	0.26	-0.901	(0.7072)
Hypothetical Elasticities :				
$Y = GO, X1 = K, X2 = L$	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)

Table 2.7: 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
$Y = GO, X_1 = K,$	K: 0.271	K^2: 0.043 [a]	KL:-0.002[b]	
	L: 0.353	L^2: 0.044	LM: -0.090	(0.9513)
$X_2 = L, X_3 = M$	M: 0.526	M^2: 0.088	MK: -0.089	
$Y = NVA, X_1 = K,$	K: 0.27 [c]	K^2: 0.088	KL: -0.172	(0.7087)
$X_2 = L$	L: 1.32	L^2: 0.055		

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

Table 2.8: 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 2.9: 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 M .42	K .20 L .63 M .07	K .15 L .25 M .61	-[b]	-
GO:TI	K .41 L .18 M .48	K .30 L .72 M .11	K .16 L .23 M .62	K .2 L .16 M .65	K .2 L .04 [c] 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 2.10: 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 2.11: 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 2.12: 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%
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%
$(\frac{Y}{L})$	4.3%	1.6%	6.3%	4%	4.4%
$(\frac{Y}{L})_{74}$	4.9%	2%	6.5%	4.7%	6.1%
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%
$(\frac{Y}{K})$	0.7%	0.8%	1.9%	-1.1%	0.5%
$(\frac{Y}{K})_{74}$	1.8%	1.6%	2.5%	0.1%	2.7%

[a] Weighted by Output share in each period and in 1974 respectively.
[b] Weighted by labor share in each period and in 1974 respectively.
[c] Weighted by capital share in each period and in 1974 respectively.

Table 2.13: 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 2.14: Aggregation over Industries - Growth Rates

Table 2.15: 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
291	General Machinery	0.136	2.1	1.7	2.7
292	Special Machinery	0.174	2.1	2.5	1.5

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Table 2.15 - continued

Code	**Description**	**DomarWt.**	**74-03**	**Pre-90**	**Post-90**
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

Chapter 3

Pre-reform Conditions and Intermediate Inputs Distortions in India

3.1 Introduction

It is often argued that the Indian manufacturing sector never really took off. There is nothing equivalent to the green revolution of the 1960s in the agriculture sector or the service sector boom of the late 1990s. Hulten and Srinivasan (1978) [47] describe this absence of a period of consistent high growth rates by saying that the Asian miracle has largely missed Indian manufacturing. More recently, Fernandes and Pakes (2008) [36] document how value added in Indian manufacturing does not compare with other developing countries like China and Vietnam for the period between 1995 and 2005. Even within India, manufacturing growth performance is not similar to that of the service sector. Using national accounts data, Figure 3.1 shows GDP and output shares of manufacturing and service sectors in India for 1960-2002. The output of manufacturing grows during these 43 years but that growth is lower than the growth in services output which starts growing exponentially after 1990s. The contrast between these two sectors becomes clearer when looking at the output shares. Share of services has been growing continuously while manufacturing share remains almost constant. If we look at the sources of growth, the numbers present an even more puzzling picture. Based on data from Bosworth and Collins (2008) [19], Figure 3.2 compares the contribution of factors and TFP for manufacturing and services growth in India and China. The growth of capital accumulation for the period between 1978 and 1993 in Indian manufacturing is same as the capital accumulation growth in Chinese manufacturing, which is contrary to the often cited explanation that Indian manufacturing lagged because of closed capital markets. It is the dismal TFP growth of 0.3% in Indian manufacturing that is responsible for the difference in output growth performances.

During the same time period, TFP growth in the service sector in India is 1.4%, almost 5 times the TFP growth in manufacturing. Effect of economic reforms in India is remarkable for both of the sectors and improvement in growth performance of India after 1994 is mostly due to acceleration in TFP growth. TFP growth average between 1994 and 2004 is 1.1% per year for the manufacturing sector and 3.9% per year for the service sector, which is almost three times the pre-reform average.

Why is it that under a similar set of economic environment the service sector grew at remarkable rates while the manufacturing sector did not? How did reforms in the 1990s change things and help in accelerating the productivity growth? What effect or improvement is this residual(TFP) growth capturing? This paper differs in its approach to answering these questions by introducing two new aspects. First aspect is the role of *intermediate inputs*, which is missing from the discussion despite it being the most important differentiator between manufacturing and services production processes. Second difference is that the paper studies the effect of *combinations* and *interactions* of policies, which can be totally different from the individual effects of the policies. Adding these two dimensions provides some insights regarding Indian economic growth experience. The paper finds that the difference between growth performances of the manufacturing and the service sectors is because the manufacturing sector relies more heavily on intermediate inputs. Interactions and combinations of policies (inflexible labor laws in presence of quota-permit system) and economic conditions (high inflation in presence of credit unavailability) in India created distortions resulting in production inefficiency. These mechanisms hampered the productivity growth by forcing manufacturing firms to operate at non-optimal intermediate input allocation. Economic reforms in 1990s helped in breaking the distortion by removing many of the restrictions and as a result, the inefficiency mechanisms disappeared. This paper discusses these economic mechanisms through which the government policies affected manufacturing firms' productivity.

In economic growth literature, the importance of intermediate inputs or raw materials has been ignored. An interesting debate on role of "perspiration" or factor accumulation vs. "inspiration" or productivity improvements has overshadowed other important aspects. Factor accumulation is treated as being synonymous to capital per worker growth. Materials are important inputs in the production process (more so in manufacturing than services). For registered Indian manufacturing the paper estimates that factor share of materials in the gross output production function is 0.6, *three times higher than capital share*. Studies on intermediate input have mostly been focused on how intermediate input amplifies the TFP growth due to aggregation. Role of intermediate inputs in promoting or, as this paper finds, in restricting economic growth is not well understood. Ever since the re-emergence of growth literature following the "Asian miracle", capital accumulation (along with alternative technological progress view) has been the favorite explanation and policy recommendation. But it seems unfair to devote all the attention to just one factor of production (capital) and ignore the other important input (material). [30] From a researcher's perspective, input factor that is in scarcity is the one that offers interesting insights into how to increase the output of an economy. This can in part explain the dominance of studies on the role of capital. But recent trends of surges in commodities prices driven by economic growth in India and China and of competition among different industries for the raw materials make a strong case for expanding our understanding of the role of intermediate inputs or materials in the economic growth process. Using simple accounting, this paper shows that growth of both gross output and value added depends on materials per worker growth. The paper also finds that for Indian manufacturing, material input was the limiting factor responsible for the observed low output growth. Estimates show that restricted materials per worker usage lowered the productivity and output growth in periods before the reforms.

To attribute any estimated effect to a policy, one needs to isolate it from other policies. But *ceteris paribus* assumption comes at a cost because interaction of different economic conditions may give rise to mechanisms or incentives that are totally different from the predicted outcomes of any individual condition. This is especially true in case of India, where different policies are not always coordinated together and are not necessarily in synchronization. Rajan, Kochhar, Subramanian etal. [68] describe development policies that India adopted after its independence as "idiosyncratic". The reason for manufacturing growth rates being relatively lower lies in the way Indian economy has evolved. By the time industrial growth started to become the focus of five-year plans, India had already embraced the socialist model of planning. Government regulations and control became entwined with Indian industry including the notorious "license-raj" (the quota-permit system) and rigid labor laws. Besley and Burgess (2002) [12] show that pro-worker industrial dispute acts tend to lower the output, investment, productivity and employment in manufacturing. Fernandes and Pakes (2008) [36]

[30] Intermediate inputs balance out when aggregated over the entire economy. Effect of imports (aggregated materials input) on growth has been studied. But this paper shows how such an effect would work.

also find that labor is underutilized in states with more restrictive labor laws (e.g. amendment to the Industrial Disputes Act which made the firing of workers illegal except with previous permission from the appropriate state government).

The question that remains unclear is that "why do these worker friendly labor laws end up reducing productivity and inducing underutilization". More importantly, why did these economic policies affect performance of the manufacturing sector but not the service sector? This paper shows that it is because of the presence of additional (often ignored) policy of quota system. The economic mechanisms, arising from the interaction of the quota system with existing conditions and labor laws, distorted the usage of intermediate inputs that are very important in manufacturing production function (share of 0.6). This non-optimal allocation of intermediate inputs resulted in inefficiencies in the manufacturing sector.

Unfortunately, the effect of quota-permit system on Indian industry has not received its due attention. Mohammad and Whalley [60] discuss some of those licenses and other controls. Their estimates of the welfare loses from rent seeking in India are as high as 30% to 45% of GNP. The main sources of rent seeking were price controls and rationing. Das [27] finds out that the structure of import licensing remained restrictive and complicated throughout 1980s and even in early 1990s. In general, labor laws have not changed dramatically and economic reforms have focused on removing these license regulations rather than labor rigidities. So the observed improvements in performance stem from the removal of quota-permit system and the reason for differences in pre-reform and post-reform performance is directly related to this quota system.

The paper argues that it is the *combination* of two different distortions of labor rigidity and material quota that is impeding to productivity. An optimizing firm has to equate its labor and material ratio such that marginal returns are equal to respective prices. But if due to labor laws it can not fire extra workers, it ends up needing more material to reach the optimal allocation. The firm cannot buy extra material because of quota-permit restriction. Hence the firm ends up operating at *non-optimal* levels. Notice that by itself none of these policies lead to the distorted allocation. Does intermediate input distortion affect productivity? Chand and Sen (1996) [23] find that liberalization of the intermediate-good sectors is better for TFP growth than liberalization of the final-good sectors. But there has not been any detailed study on why that is the case. Similarly, research is also lacking in finding the role of intermediate inputs in affecting productivity in India.

The *inefficiency mechanism* discussed above hinders productivity more severely when there is high inflation and less access to credit markets. This was exactly the case in India before the reforms, especially in 1970s. There are many studies on inflation-growth nexus. Barro (1995) [8] and Chari, Jones and Manuelli (1996) [24] show that lowering inflation increases the GDP growth rate. The link works through effecting returns to savings and thus capital accumulation. This paper provides another perspective on role of inflation in affecting growth in Indian manufacturing. Inflation combined with credit unavailability forces firms to operate at non-optimal input allocation because they can neither reduce labor (due to labor laws) nor afford to buy materials (credit constrained and significant increase in materials prices due to inflation). The paper finds a strong relationship between materials inflation and real wages (labor productivity) indicating the presence of this channel.

The paper also contributes to two other streams of research, namely labor market regulations and import substitution policy in India. Ahsan and Pages (2007) [64] find that in India pro-worker labor policies are associated with reduced productivity growth. Kruger (1997) [55] discusses how it was thought that import substitution in manufactures would be key to development. Bruton (1998) [20] compares the earlier trend of import substitution to "new orthodoxy of outward orientation". The industrial quota permit policy in India was motivated by this import substitution view. Earlier explanations about both these observations, i.e. labor laws slowing growth and import substitution policies slowing growth, are based on calculating implicit costs or wasted resources. This paper finds a direct channel (intermediate inputs) and distortion mechanisms through which productivity is affected. The paper also shows how these policies interacted with each other and with existing economic conditions unfavorably and ended up being responsible for lower productivity growth.

One of the major impacts of economic reforms in India was to break these interactions by removal of permit quotas and increase the credit availability. Aforementioned *distortion-inefficiency* channels no longer remain relevant because firms are not restricted when choosing their material input allocation (labor firing restrictions have still not been removed). The paper finds that the distortions in input allocation and their effect on productivity growth reduced significantly after the reforms in 1990s. Estimates also show that firms have started oversubstituting materials relative to labor. This explains the phenomenon of jobless growth in Indian manufacturing. Firms are growing because of *material-deepening*, but they are avoiding hiring additional workers to avoid future inflexibilities and legal issues. Like many other studies, this finding calls for policy makers to look at the labor market regulations in India.

The rest of the paper is organized as follows. Indian economic environment and policies are discussed in next section. The paper shows basic growth accounting setup with materials and explains the interaction of these policies and their effect on productivity via distorted materials usage. Two sets of input distortion measures are calculated and the impact of these distortions on productivity estimates is discussed. The paper then talks about how reforms changed these mechanisms.

3.2 Pre-reform Conditions in India

Industrial sector became the focus and one of the early goals of five-year plans of Indian government. Just like every other part of the economy, Indian manufacturing has experienced the evolution of policies and markets in last three decades. It has been the subject of many productivity and policy research studies, but often for the wrong reasons. Unlike other sectors in India and unlike manufacturing sectors in other developing countries, the manufacturing sector in India did not register many years of consistent high growth until very recently. GDP (at 1993-94 prices) of manufacturing has grown almost 10 times between 1960 and 2002. But unimpressive productivity and TFP growth rate estimates from various studies have portrayed Indian manufacturing as a stagnant sector with little effect of early stages of policy reforms. Das (2003) [27] finds a negative TFP growth over the period of 1980-2000 and attributes this to structural factors. Madheswaran and Rath (2004) [69] argue that even though TFP in many industries improved, it was driven by technical progress and all technical efficiency changes were negative. Another branch of research tries to find the explanation for this relatively slower growth. The probable causes include inflexible labor laws which make it difficult for firms to lay off workers. But the literature does not discuss three other equally important characteristics of the economic environment under which Indian firms were operating. First is that in addition to the usual import tariff, India also had quantitative restrictions on many of the commodities. Second is the inflation in 1970s which was very high. Third is the lack of easy access to credit for the firms. This paper explains how the combination of these three conditions and the labor market regulations led to non-optimal factor allocation in manufacturing which resulted in reduced productivity growth. It affected only the manufacturing sector because these inefficiency mechanisms worked through distortions in intermediate inputs usage.

3.2.1 High Inflation

Inflation has been consistently high in India. Annual average CPI inflation has been 8.2% per year between 1970 and 2003. Pre-90s and post-90s inflation rate averages are 8.6% and 7.4%, both much higher than average inflation in industrialized and newly industrialized countries. For China, the average retail price inflation between 1978 and 2003 is around 5%.

Barro (1995) [8], in the study of 100 countries between 1960 and 1990, finds that increased inflation reduces GDP growth after accounting for country characteristics. Chari, Jones and Manuelli (1996) [24] explain this relation quantitatively using endogenous growth model. Changes in inflation rates affect the real rate of return to savings and thus growth. But not many studies have looked into the role of inflation in Indian economic growth. This is despite the fact that high price increases, especially in the 70s and the 80s, motivated many of the policy interventions.

Intermediate input prices have also experienced the same kind of high inflation throughout the last three decades. The average annual inflation rate of materials prices is 7.5%. Using industry specific price index data from Central Statistical Organization, the paper calculates the average inflation rate for each of the 58 industries. The average inflation is higher than 7% per year for 53 of them with few industries experiencing price increases averaging more than 11% per year between 1973 and 2003.

Inflation matters in more ways that just the "shoe-leather costs". For example most business income tax systems are not indexed for inflation; i.e., depreciation allowances are not indexed to inflation. So if inflation becomes high, the real deduction for depreciation becomes too low. Profits are way overstated, real tax burdens can exceed 100% and companies with lots of long life assets go bankrupt. This happened in the 1970s in the UK and other countries.

Despite these issues, it is true that inflation by itself does not have any direct negative effect on productivity growth and even if it does, the effect on manufacturing and service sectors should be the same. But combined with the limited access to credit market, high inflation in material prices forces firms to use less material per labor and hence reduces the productivity. Concurrent inflation in labor prices (increase in wages) combined with the inability to reduce labor allocation makes this distortion (sub-optimal materials usage) worse and productivity growth lower. Inflation rates for materials prices and for wages are very high. For the period between 1970 and 2003, annual nominal wage inflation in Indian manufacturing is 9.6% with nominal wage increase of 11.1% per year before 1990 and 7.1% increase per year after 1990.

3.2.2 Low Credit Availability

It was the currency crisis of 1991 in India that paved the way for a broad set of reforms including capital market reforms. Prior to that, credit markets in India were unorganized and underdeveloped. Figure 3.3 shows the lending rates of various countries using data from International Financial Statistics. For India, it is 16.5% for the entire decade of the 80s. It is not only higher than in developed countries such as United States and Germany but also higher than other Asian economies like Singapore and Malaysia. Interest rate, which denotes the cost of borrowing, remained very high in India until late 1990s. Credit markets were also underdeveloped. Table 3.1 shows stock market capitalization in 1990 for different countries. For India, market capitalization as percentage of GDP is much lower than for other countries.

The role of financial markets in economic growth has been discussed in many studies. King and Levine (1993) [52] find that various measures of financial development are strongly related to GDP growth. The relationship works by promoting efficient capital accumulation and thus inducing the increase in output. The paper discusses a more direct role of finance in the context of Indian manufacturing. Consistent increase in input prices each period requires firms to look for credit if they want to keep operating at the same scale. Lack of credit arrangements means that firms need to pay at the beginning of the period while their output will be sold (even if at higher prices than last period) at the end of the period. Firms have the money from sale of output last period, but if material prices go up significantly it might not be enough for buying sufficient intermediate inputs or materials. This forces firms to use less material per worker resulting in reduced output per worker and thus lower productivity growth.

Why do firms not operate at the new optimal allocation for the given prices and their budget constraint? It might have been possible for firms to do that by reducing the labor as well. But unfortunately in India firing workers is not easy due to government laws. This restriction in adjustments to the labor input makes the situation worse because of nominal wage inflation. Not only did the firms fail to achieve their potential output, but they have to pay more to their over-optimal allocation of workers. This continues the reduced productivity cycle in the next period: reduced growth due to distorted materials usage leading to less cash, then inflation next period means more severe distortion again, and so on. It provides an explanation for the observed persistence of the productivity slump in Indian manufacturing before mid-1990s.

3.2.3 Inflexible Labor Laws

The *Industrial Disputes Act* of 1947 states that “dismissal of an individual workman to be deemed to be an industrial dispute”. This law has motivated many studies on the role of labor market regulation in India. Labor regulation has become a standard part of the explanations for India’s poor growth performance before 1990s. Besley and Burgess (2002) [12] show that states which made amendments to this act in pro-worker direction experienced lower output and productivity in Indian manufacturing. They also find that pro-worker labor regulation is associated with increases in urban poverty. Fernandes and Pakes (2008) [36] use World Bank Investment Climate Survey data to show that conditional on firm productivity, other factors and factor costs faced by firm, labor is underutilized in Indian manufacturing in 2001 and 2004. The supposed explanation is that these inflexible labor laws restricting the firing of workers in India resulted in firms lowering their demand for labor. Ahsan and Pages (2007) [64] discuss various types of labor laws in India, including Chapter Vb of amendment to the Industrial Disputes Act which prohibits firms that employ 100 or more workers to retrench without permission from the state. There are around 45 pieces of central legislation covering various aspects of employment as well as a large number of state laws. Even shifting the weekly schedules or days offs without notice could be in non-compliance. Ahsan and Pages (2007) [64] find that regulations that impede employment adjustment are associated with negative effects on output.

These previous studies on estimating the effect of labor market regulation in India on growth have stressed mostly on the explanation that these regulations add implicit extra cost. But how does that extra cost translate into lower productivity? The paper provides the explanation for “labor law leading to lower productivity” observations by showing that these worker friendly laws interacted with other economic conditions and policies. Because of these interactions firms were restricted to choose sub-optimal input allocation. This led to lower labor productivity and wage growth. Intermediate inputs or materials were the channels by which the policies interactions took place and hence the severity of the effect on growth is different between manufacturing and service sector.

The paper argues that these labor laws in presence of quota permit system generated following economic mechanisms. The number of workers in a firm became inflexible (could go only upwards) and when the amount of materials that was available to the firm was also restricted due to industrial policy of permit-quota, the input factor allocation in the manufacturing production process became distorted (less than optimal materials per worker for the given prices). Firms had too many workers and too little materials. They were restricted on both dimensions. They could not reduce one (workers) easily and neither could they increase the other (materials) easily. Hence they were made to operate with this *forced* production inefficiency.

3.2.4 Quantitative Restrictions - Quota Permit

In his 1978 book Bhagwati [13] talks in detail about quantitative restrictions which were the building blocks of industrial policy in India. These were guided by principal of *import substitution* and were justified by the aim of protecting the domestic producers. Commodities were divided into various categories and producers needed to apply for license for items not under OGL (open general license). Licenses were required for producing new products or expanding production capacities. Mohammad and Whalley (1984) [60] estimate that the cost of these rent seeking policies in India was as high as 30% to 45% of GNP and it "put India in a different category altogether".

Despite being one of the most widely criticized policy choices, not many studies have tried to identify and estimate how this quota system affected the growth in Indian manufacturing. Bhagwati (1970) [14] documents the industrial licensing scheme adopted in India after passage of The Industries (Development and Regulation) Act of 1951. There were separate license categories. CG (capital goods) license was required to import necessary capital goods. The AU (actual user) licenses issued to producers for imports of raw materials and intermediates had items specified in considerable detail to ensure that only the approved production would be made feasible. This also required that value and/or quantity limits were specified for the listed importables on each license. These licenses even specified the composition and the source and were non-transferable between firms and even between plants within a firm. This licensing system was inefficient since it lacked any evaluation criteria and there were large administrative costs and delays.

Previous studies that have tried to measure the effect of this policy use the approach of estimating the cost in terms of wasted resources, time and opportunity cost. But the quota permit policy affected Indian industries in more ways than just increasing the fixed cost. These restrictions and license requirements meant that firms were not free to choose the raw materials and intermediate inputs freely based on the prices. This paper discusses a direct effect of quota restriction on the labor productivity and its growth, which has been ignored until now. Quota policy creates input distortions in presence of the inflexible labor laws which is not recognized when studying the policy in isolation. The distortion occurs because these two policies restrict the choice set of producers. Labor laws put a lower bound on the number of workers firms can choose in the output production process. Labor can only go up from the current allocation. Quantitative restrictions and permit license put an upper bound on the materials and intermediate inputs a firm can use. These two together create situations where a firm might be forced to operate at non-optimal allocation for the given prices. In general this would mean that the firm is using less than optimal materials per worker. This paper measures the degree of restriction in input choices by estimating the difference between the optimal and the actual allocation. This distortion and consequently its effect on productivity does not pertain to service sector, since services production depends mostly on capital and labor and not as much on raw materials and intermediate goods covered by the industrial licensing regime.

To get an idea of severity of these restrictions, one can look at the implied protection rates due to these quantitative restrictions. Bhagwati (1970) [14] estimates this by calculating the differences between the actual value-added and the hypothetical value-added with just the import tariffs. Estimated average protection rates due to quantity restrictions are four times higher than the protection rates due to actual import tariffs. In 1961-62 the protection rates due to quantitative restrictions are in the 60% to 80% range when measured at domestic prices and even higher when measured at international prices. These estimates mean that value-added of industries was reduced by as much as 80% in 1961 due to the quantitative restrictions. Put another way, in 1961 the value-added of Indian manufacturing would have been 80% higher if these restrictions were not present. The paper identifies the channels by which the restrictions resulted in reducing the value-added by so much.

3.3 Interaction of Policies via Intermediate Inputs

The four factors mentioned in the last sections should have had no direct effect on efficiency. But in the presence of others, they created economic mechanisms that hampered growth. In addition, these mechanisms worked through intermediate inputs and hence especially affected the manufacturing sector. The paper discusses these interactions and mechanisms in detail.

1. High Inflation in presence of Credit Unavailability
2. Quota Permit in combination with Labor Restriction

Inability to reduce workers combined with fixed quota of materials led many firms to operate with less than required (optimal) inputs. This distortion not only restricts the output, it also reduces worker productivity. If, due to technological improvement, it becomes possible for a worker to convert more input into output than the last period, this technological progress will not translate into productivity improvement. The firm needs to either get a permit to increase its materials quota or it will have to get approval for reducing the labor, both of which lead to rent seeking by government officials and firms therefore try to avoid it. Thus firms end up operating at the restricted allocation and do not experience the possible output and productivity growth. This should show up as reduced materials usage compared to labor allocation. The paper measures this relative underutilization (and also estimates the corresponding under-substitution in each period).

The second mechanism of high input prices combined with difficult credit availability leads to inefficiency in a similar kind of manner. Inflation might reduce output growth because input factors need to be paid at the start of the period while payment for output is received at the end of period. This means that a consistent and high inflation will lead to sub-optimal allocation (compared to a low inflation case). The situation is more relevant when there is lack of capital market and/or interest rates are high (which is exactly how things were in India). If input prices go up, a credit constrained firm can no longer afford to buy the same amount of materials. This reduced materials usage lowers labor productivity. The paper checks the relationship of productivity estimates with materials growth and with labor growth.

3.3.1 Growth Accounting with Materials

To see the role of materials-per-worker ratio in output growth, let us consider a simple extension of Solow's growth accounting model by including materials as input in the constant return to scale production function.

$$Y = AK^{\alpha}M^{\beta}L^{1-\alpha-\beta} \tag{3.1}$$

This can be rearranged in gross output-per-worker terms as

$$\frac{Y}{L} = A(\frac{K}{L})^{\alpha}(\frac{M}{L})^{\beta} \quad \Rightarrow y = Ak^{\alpha}m^{\beta} \tag{3.2}$$

Growth rate of output per worker between two periods can be expressed as following.

$$\Delta y = \Delta A + \alpha * \Delta k + \beta * \Delta m \tag{3.3}$$

Labor productivity growth is weighted sum of TFP growth, capital per worker growth and materials per worker growth. Third term in Equation 3.3 which denotes *materials deepening* is the one that, although missing from the literature, can be of crucial importance in explaining economic growth in a country. Estimated values of $\beta = 0.6$, $\alpha = 0.2$ for Indian manufacturing indicate that materials per worker is very important (more than capital per worker) in growth accounting.

The value-added is obtained by subtracting the value of intermediate inputs from gross output. In that production function only labor and capital should be used as input. Hence, ignoring the role of materials growth should not be a big deal. But that is not the case. We can see that there is a relationship between value-added growth and materials growth. The value-added Y_1 and value-added per worker can be written as

$$Y_1 = Y - P_M * M \tag{3.4}$$

$$y_1 = Ak^{\alpha}m^{\beta} - P_M * m \tag{3.5}$$

This simple accounting equation contradicts the notion that value added production is independent of materials used or that materials-per-worker ratio does not affect growth in value added. It highlights the cost of such a simplification. In fact, *Domar weights* and *Terms of Trade decomposition* methodologies take care of these issues regarding intermediate inputs [31]. But even though the effect of materials per worker in economic growth is clear from Equation 3.5, this fact is not stressed enough. The reason is that ideally this input (materials) should have been allocated to equate the returns between factors. Hence, concentrating only on "extensive margin" (supposedly, the capital input) of output growth makes sense in general. But government policy (or in case of India, the interaction of government policies) can distort the materials input allocation compared to the other

[31] See Gupta (2008) [45] for detailed estimation results of growth in Indian manufacturing using these two methods.

inputs and this can have negative effect on the growth. The paper defines and estimates some measures of this distortion by comparing it to the (hypothetical) optimal allocation.

3.3.2 Distortions and Inefficient Substitution

Presence of the channels that transfer the effect of interaction of policies (labor laws in presence of quantitative restrictions) and economic conditions (high inflation with low credit access) to the production process can be verified using the data. From production function estimates, one could identify whether the ratio of labor and materials is higher than or lower than the optimal $\frac{L}{M}$. Higher $(\frac{L}{M})$ means either using more workers (since firms cannot fire them) or using less material (due to quotas).

We can see how these ***distortion-inefficiency*** channels work in different scenarios by considering a simple production model $Y = f(A, K, L, M)$ where output Y is produced using capital K, labor L and materials M. A is the measure of production technology and other unobservable inputs. Optimization gives the following first order conditions for input allocation in terms of price of labor w and price of materials p_M.

$$w \propto \frac{\partial Y}{\partial L} \tag{3.6}$$

$$\frac{(\frac{\partial Y}{\partial L})}{(\frac{\partial Y}{\partial M})} = \frac{w}{p_M} \tag{3.7}$$

For Cobb-Douglas production function Equation 3.7 reduces to

$$\frac{\alpha_L}{\alpha_M} . \frac{M}{L} = \frac{w}{p_M} \tag{3.8}$$

In response to a positive technology shock, wages go up due to increased productivity. Since intermediate input prices are determined in the world market, optimality represented by Equation 3.7 requires either $(\frac{\partial Y}{\partial L}) \uparrow$ or $(\frac{\partial Y}{\partial M}) \downarrow$. Under usual assumption of concavity, this can be achieved by either using more materials or using less labor. Quantitative restrictions do not allow a firm to use more materials. Inflexible labor laws prohibit a firm from using fewer workers. The optimality represented in Equation 3.7 is never achieved. Due to these frictions, the gains from the technological progress are not fully realized and firms are forced to operate at non-optimal factor allocation.

Using Annual Survey of Industries data between 1970 and 2003, the paper finds robust estimates for production function parameters [32]. The paper also calculates the optimal $(\frac{M}{L})$ for all-industries and for each of the 58 industries using 3-digit NIC code panel data.

The second distortion mechanism operates through rising prices and limited access to credit markets. Let us consider the effect of high inflation in materials on factor allocation choice of a firm. In absence of credit it can no longer afford to buy the same amount of materials due to increased price. The firm can still operate efficiently by shrinking its scale and lowering the labor input accordingly. But even that is not possible. Since it is difficult to fire extra workers most of the firms have to compromise on materials and end up having less materials allocated per worker. This causes the output to go down and hence reduces productivity growth. This effect is summarized in Equation 3.9. The paper shows the presence of this channel by estimating the relationships of productivity growth with input growths and with materials inflation.

$$p_M \uparrow, \ \underline{L} \quad \Rightarrow \quad (\frac{M}{L}) \downarrow \quad \Rightarrow \quad (\frac{\partial Y}{\partial L}) \downarrow \tag{3.9}$$

The paper measures these period-wise substitutions between factors. For each year, the paper also estimates all-industries and industry-specific output growth rates, input (K,L and M) growth rates and productivity (single-factor and total-factor) growth rates. These estimates and their relationships with different measures of distortions are discussed in the next sections.

One point about these channels is that they operate via intermediate input distortions. Hence these mechanisms do not affect the service sector because intermediate inputs are not that important in services production. In contrast, for Indian manufacturing the share of materials in gross output production function is around 0.6, much higher than the share of labor and capital. This is why Indian manufacturing growth rates are worse than that of services despite facing similar economic conditions and policies.

3.4 Measuring the Distortions

There have been few studies on trying to estimate the extent of distortions in factor allocation. Klenow and Hsieh (2007) [53] quantify the misallocation by comparing marginal products of labor and capital in industries in India and China with those in US. Fernandes and Pakes (2008) [36] estimate the

[32] See Gupta (2008) [45] for detailed estimation results.

underutilization of labor and capital across states in Indian manufacturing in 2001. The paper uses a similar concept. But rather than estimating the absolute values, the paper measures the distortions (under or over utilization) relative to the other factors. This is better because if one tries to measure the misallocation or underutilization by amount of extra labor that will be required to justify the wages, he or she is assuming that capital is already optimally allocated, which defeats the purpose of this counter-factual exercise. Measuring the relative distortions does not depend on these assumptions and for Cobb-Douglas specification (used in this and most of the other papers), this ratio based relative underutilization measure is directly related to productivity growth. Another problem with the earlier approaches is the implicit assumption that the TFP estimates represent the unit-production-values i.e. if one amount of each input is employed, the output will be equal to the value of TFP estimate for that period. This seems harder to justify given that there are measurement errors, and we are ignoring many of the inputs such as education, economic conditions etc. TFP residuals represent estimated measure of all the unmeasurables and production technology is just a part of it. So it makes more sense to rely on changes in TFP or on TFP growth rather than the absolute value. Doing this exercise for changes or growth rates should not be subject to such criticisms. The paper also develops and estimates analogous measures for substitution between time periods.

1. $OverUtilization = Actual\frac{L}{M}\ \ (Prices) - Optimal\frac{L}{M}\ \ (Prices)$
2. $OverSubstitution = Actual\frac{\Delta L}{\Delta M}\ \ (\Delta Prices) - Optimal\frac{\Delta L}{\Delta M}\ \ (\Delta Prices)$

The first measure estimates the extent of distortion by comparing factor allocations to the optimal value. The optimal value is an allocation that firms would choose if there were no frictions (e.g. quotas or labor laws) and it is obtained by finding output maximizing allocation using production function estimates. The paper calculates this optimal allocation ratio by equating the marginal product to price ratio of two factors at the given prices in that period. The substitution measure estimates the effect of these restrictions by finding how close firms are to the optimal response in substituting between factors. For example, even if price of labor relative to materials goes up, firms cannot reduce labor allocation due to inflexible labor laws and neither can they increase materials input because of quota permit system. Hence the actual changes in input choices will be different from the optimal response and the second set of measures used in the paper captures this distortion. These substitution distortions do not depend on the parameter values (e.g. factor share in Cobb-Douglas).

The paper also calculates over or under utilization and substitution of capital relative to labor and materials. These sets of measures are also converted to ratios and distances from optimal.

Using data for all-industries, Figure 3.4 plots the movement of actual vs. the optimal ($\frac{M}{L}$) ratio. Compared to 2003, actual materials per worker index is lower than what the optimal should have been for existing wages and materials' prices in each period. The paper finds that for the entire period (1970-2003) materials are on average 25% underutilized compared to labor and this average reduces by half (i.e. 12%) after the reforms in the 90s. When estimating with 3-digit NIC code panel dataset, unweighted average underutilization of ($\frac{M}{L}$) over 58 industries is almost same as all-industries (24% for the 1973-2003 period and 11% for the post-reform period of 1991-2003).

Similarly, the estimates also show that compared to labor, capital input is being overutilized in the later periods. These results are similar to those of Fernandes and Pakes (2008) [36], who find overutilization of capital in 2001 and 2004. This happened because capital prices dropped significantly after 1990s and Indian manufacturing firms started oversubstituting capital especially relative to labor. The reason for this trend is that reforms have not changed the labor laws. Firms still need to get government approval to fire workers and such approval is rarely given. Expecting these issues, firms prefer to not hire workers and oversubstitute other factors (capital and materials) compared to what is optimal at the existing prices. This leads to the observed overutilization.

The paper finds that between the two periods, some industries (specified by 3-digit NIC code) are oversubstituting materials relative to labor for the observed movement in prices. This observed presence of oversubstitution of materials relative to labor in the 70s and 80s does not imply that few firms somehow got around the licensing requirements. It simply means that even when wages went down (relative to materials prices) firms did not hire more workers. Firms might have done this because of two reasons. Their input factor allocation was already distorted and materials were underutilized, so firms did not want to increase this distortion. Another reason might be that these forward-looking firms expected that in the future they will not be able to get the extra materials required to make these workers more productive and neither will they be able to fire these workers if relative prices change again. So they chose not to hire extra workers even when it was optimal to do so at the existing prices. The estimated average of oversubstitution of materials relative to labor for all-industries is around 3.6% per year. But this varies period-wise with average being 0.7% in the 70s and 7.2% between 1996 and 2003. For the years after the reforms, this oversubstitution of materials relative to labor is continuously increasing despite the fact that materials are no longer underutilized relative to labor. This trend indicates producers' unwillingness to hire workers due to labor market inflexibilities and firing costs, because firms have already surpassed their optimal relative materials (material-per-worker) allocation.

3.5 Impact on Productivity Growth

The widespread distorted input usage in Indian manufacturing adversely affected its growth performance. In the 33 years covered in the dataset (1970-2003), the average of gross output growth rates in Indian manufacturing is 6%. But materials usage grew at an average of 6.5% during this period while average labor growth rate is just 1.1%. This lack of growth in labor input is what many believe is one of the major challenges facing Indian economy. Rajan, Kochhar etal. (2006) [68] ask whether India can foster growth in labor-intensive manufacturing. Bhalotra (1998) [15] criticizes the World Bank explanation of attributing the decline in factory employment to acceleration in wages.

If we look at the period-wise averages of estimated growth rates as shown in Table 3.2, we can see that firms are trying to avoid hiring workers due to perceived issues in firing them later and instead compensating for the lower materials per worker (underutilization estimated in last section) by continuously increasing their materials usage. This results in increased labor productivity growth which averages 6.2% for the sub-period of 1981-1990 and 6.9% for 1998-2003.

The interaction of quota permit and labor laws leads to less than optimal materials per worker and thus slows down the labor productivity growth. This mechanism is identified by finding the correlation between underutilization and productivity growth. Similarly, combination of high inflation in materials and less developed credit markets reduces the intermediate input usage in response to price increase which in turn results in lower labor productivity. This second mechanism is recognized by looking at the relationship of materials inflation with productivity and real wages. The paper estimates these two channels for aggregate data (all-industries) and panel data consisting of 58 industries based on 3-digit NIC code. Summary of main relationships for panel data are shown in Tables 3.3 and 3.4 and the estimates are plotted in Figures 3.5 and 3.6.

For both panel and aggregate data, underutilization of materials is negatively correlated to labor productivity and its growth rate. More interestingly, the underutilization of $(\frac{M}{L})$ is also negatively related to TFP growth. Labor productivity relation is simply an implication of distorted or farther from optimal input allocation. But it is not obvious why TFP growth should be affected by materials and labor usage. One explanation can be that this underutilization gives rise to other inefficiencies as well. For example, to work with less material input per worker, the production process needs to be reorganized and machines run fewer hours per week. This change in schedule can cause disruption and lower productivity.

Distortion measures (under utilization and substitution) are negatively related to TFP growth because of the nature of the policies. Labor is bounded by below and material input has an upper bound. Since $(\frac{M}{L})$ is lower than optimal at existing prices, any change that makes this underutilization worse is going to increase the inefficiencies. That is why labor growth is negatively related to TFP growth and materials growth is positively related to TFP growth (because of $\uparrow$ & $\downarrow$ in distortions). [33]

Labor productivity measured in net value added terms is negatively related to labor growth due to decreasing marginal product. The estimates show that net-value-added labor productivity is positively related to materials growth. This highlights the importance of material input in economic growth. The reason behind this result is the widespread underutilization in materials in Indian manufacturing. An increase in material growth helps reduce this distortion and enables the worker to increase his net-value-added.

The reason OECD and other statistical agencies like value added in manufacturing is because it makes it easier to compare across hugely different industries (e.g. shoe making and chemical processing). In developed economies where materials or intermediate inputs allocation is not restricted and is therefore optimally allocated according to prices and wages, using value added is better. But in case of India, this approach has come at a cost of not recognizing these important distortions and their effects on productivity. When workers are allowed to use more materials they can produce more output and also add more value, since total value added by a worker depends on how much value he adds in one unit of output and also on how many such units of output he produces. This value-added will depend on

[33] In absence of proper causality result, one can also argue that whenever firms hired more workers they increased inefficiencies because of the implicit costs of labor market regulations (e.g. possibility of strikes, disputes). But it seems unlikely that new workers can have negative effect on productivity.

materials being used if materials usage is restricted or non-optimal. For Indian manufacturing, this growth in value added labor productivity by using more materials is being driven by the fact that firms are not able to equate the marginal products on the two factors due to interaction of policies.

Estimates show that productivity growth measures are negatively related to under-substitution of materials relative to labor and positively related to growth in materials usage. These results support the presence of *distortion-inefficiency* channels operating through interaction of policies. Under-substitution means worsening of distortion and hence lesser materials per worker which results in lower productivity growth. Increased materials usage helps in taking the input allocation closer to optimal and increases the productivity growth. The paper also finds that intermediate input (materials) price inflation is negatively related to real wage inflation. This is because in absence of credit availability rising materials prices mean less materials per worker and thus reduced labor productivity. This is reflected as change in the real wages. Overutilization of capital relative to labor has positive correlation with labor productivity, which is the usual capital deepening effect.

The results of this analysis using Indian manufacturing data confirm the presence of the distortion-inefficiency mechanisms discussed in earlier sections.

3.6 Role of Reforms

India's current phase of economic reforms began in 1991 when government faced an exceptionally severe balance-of-payments crisis. Congress government at the time started short-term stabilization processes followed by longer-term comprehensive structural reforms. In 1991, government of India adopted the *New Industrial Policy*. It abolished industrial licensing for all industries (except few), irrespective of the levels of investment. This industrial policy was supported by trade policy which removed import restrictions and liberalization of foreign direct investment as part of the multi-faceted gradual reform process. Ahluwalia (2002) [3] outlines and evaluates these sets of structural reforms. Indias reform program also included wide-ranging reforms in the banking system and the capital markets relatively early in the process, with reforms in insurance introduced at a later stage.

These reforms broke down two major links which were responsible for distorted input usage and lower productivity growth. Removal of quantitative restrictions means that firms are no longer forced to operate at sub-optimal level. Firms still cannot reduce the number of workers, but they can increase the intermediate inputs usage (and capital usage) and make the allocation optimal for given prices. Similarly, easy credit access means that firms can reach this optimal even in the periods of high inflation. Firms can borrow the money, use the optimal inputs and repay the loan after selling the output (because higher intermediate input prices usually mean that output prices are also higher).

The estimated growth rates and relationships among them in Tables 3.3 and 3.4 clearly show the positive impact of the reforms. After the reforms, materials growth average is around 7% per year between 1991 and 2003 for all-industries. The effect of materials growth on labor productivity growth and TFP growth amplifies after 1991. The pooled OLS coefficient between materials growth and labor productivity growth is 0.7 for the subsample 1991-2003, more than double the value for the entire time period of 1970-2003. The increase in coefficient value implies that materials growth is becoming more important in labor productivity growth. Increase in import of various intermediate inputs driven by lifting of restrictions is shown in Figure 3.8. Firms which were forced to operate at less than optimal $\frac{M}{L}$ ratio due to quota restrictions have now started moving towards their potential productivity by importing and using more intermediate input. Growth estimates in Table 3.2 confirm that the material growth is responsible for most of the output growth in last sub-period (1998-2003). As mentioned earlier, some of the estimation results are contrary to the conventional wisdom that suggests that growth in net value added should not depend on materials at all. The paper finds that labor productivity growth and TFP growth measured in value added terms is also strongly correlated with growth in materials usage. This relationship becomes stronger after the reforms (pooled OLS coefficient is 0.48 for subsample of 1991-2003 compared to 0.18 for the entire time period). The relationship between intermediate input inflation and real wages breaks down after the reforms. The coefficient is close to zero and no longer significant after 1991. The reason is that the inflation productivity mechanism was being driven by low credit availability. Reforms increased the credit availability by liberalizing the capital markets.

Another important consequence of economic reforms is that one of the restrictions applicable only to the manufacturing industries has been removed. Import quota and industrial licensing policies abolished during the reforms were more relevant to the manufacturing sector.

3.6.1 What Happened between 1991 and 2003?

During the 1980s, India's fiscal and trade deficits kept growing. When oil prices jumped in 1990, India faced the external payment crisis and had to ask IMF for help. Indian government had to implement macroeconomic reforms as part of its loan agreement with IMF. Topalova (2004) [72] describes it in detail. The government controls were reduced in trade and the restriction on imported intermediate inputs were removed. Ahluwalia (2002) [3] points out that capital goods and intermediates became freely importable in 1993. Domestic producers who were constrained earlier, started using these imported intermediates freely to give their workers appropriate amount to work with. Figure 3.8 shows the growth in imported raw materials and intermediate inputs. There is a distinct jump after the reforms. The growth rates of all the imported items other than the coal increased significantly. This shows up as the increase in growth rate of material usage in Indian manufacturing (Table 3.2).

The continuous increase in the material content of the output, as shown in Figure 3.7, indicates that the Indian manufacturing is becoming more *specialized* or high-end. But the production of (low valued) intermediate goods is not being outsourced to unorganized manufacturing sector in India; as both the output share and the output growth rate of unorganized manufacturing have gone down in the recent years. Figure 3.9 shows the share of unorganized manufacturing in the total manufacturing output and the growth rate of output in unorganized manufacturing. Both have gone down after the reforms. This reaffirms the belief that only the *imported intermediate-inputs* were the bottlenecks. The Indian manufacturing firms were not restricted in their allocations of the raw materials and the intermediate-inputs that were domestically available. But these goods were not the perfect substitutes for the quota-restricted imported intermediate inputs. The production functions of the manufacturing firms (e.g. chemical, semi-conductors, electronics, specialized goods) often have Leontief type of complementarity between intermediate inputs. The restriction on freely choosing these goods made it a *bottleneck* that choked the productivity growth in Indian manufacturing. In fact, the concurrent trends of the increase in the growth rates of imported intermediates and the decrease in the growth rates of unorganized manufacturing output are consistent with the mechanisms discussed in the paper. Since there were no restrictions on buying domestically (often by the unorganized manufacturing sector) produced raw materials, the reforms had no direct effect on these. But the firms which were earlier using the domestically produced (imperfect) substitutes, started reducing their reliance on these domestic goods after the reforms and started importing the desired intermediate inputs. This is why the output growth rate of the unorganized sector goes down after 1995 in Figure 3.9.

The growth estimates in Table 3.2 also show two other interesting trends. The capital input growth jumped to around 9% per year for the sub-period between 1991 and 1997, but it goes down significantly after that. The total factor productivity shows the opposite trend. The estimated average TFP growth rate becomes slightly negative for the sub-period just after the reforms, but it is an impressive 3% for the period between 1998 and 2003 (5% for the value-added). The disinvestment and privatization initiatives undertaken in 1998 are also responsible for the negative growth rates of K and L in the last sub-period (1998-2003).

The reforms liberalized the foreign direct investment and in 1993, foreign investors were allowed to purchase shares in Indian stock markets. This led to the spectacular increase in growth rate of K input, but this increase does not seem to be accompanied by the total factor productivity growth during that time. TFP estimates for that sub-period are negative. Even the panel data analysis shows that the TFP of Indian manufacturing firms went down in the period after the reform.[34] One explanation is that when the government introduced the capital market reforms, there was a rush to take advantage of the increased capital availability and the lower capital prices. The investment went to the unproductive industries and firms as well. Once investors became more cautious, the capital started going *only* to the productive firms. The other explanation could be that the firms and the investors were not sure how long the reforms would last. They decided to use the opportunity to build up their capital stocks and made large investments. Once they realized that the reforms are here to stay, they stopped stockpiling the capital. Figure 3.10 shows the growth rates of K input and HP filter trends in those growth rates for public limited, private limited, corporate and public corporation manufacturing firms. The big sudden drop in 1998 for the public corporations is due to the privatization drive started by the BJP government. The non-performing units were closed down and hence there was the drop in K and L (negative growth). It also resulted in the observed jump in the TFP growth rates after 1998.

The service sector boom in the late 1990s also affected the labor input growth in the Indian manufacturing sector. Figure 3.11 shows the scatter plot of wage growth and employment growth for the period between 1998 and 2003 using the panel data. The correlation between the wage growth

[34]See Gupta(2008) [45] for details.

and the employment growth is negative. It means that the workers with increased productivity were leaving their jobs. This trend is also verified by looking at the median wage rate and labor-share weighted average wage rate in Indian manufacturing, as plotted in Figure 3.11. The weighted average wage rate grows slowly and becomes lower than the median wage rate in the late 1990s, because the share of labor in higher wage rate industries is going down due to attrition of their workers. This trend seems to be guided by economic incentives. Since more productive workers (i.e. workers in high wage rate or high wage growth industries) are likely to be the ones with higher education, they have higher chances of making the successful moves to the expanding service sector.

The results in the paper show the importance of the new trade and industrial policies in unblocking the distortions that were affecting the productivity growth in Indian manufacturing sector before the reforms. We can get a rough estimate of the importance of these reforms by using the output per worker relation.

$$ln\frac{y^{potential}}{y^{actual}} = \beta * \frac{m^{optimal/free}}{m^{actual/restricted}} \tag{3.10}$$

$$\Delta ln\ y^{potential} - \Delta ln\ y^{actual} = \beta * (\Delta ln\ m^{optimal} - \Delta ln\ m^{actual}) \tag{3.11}$$

In the above equations, β is the Cobb-Douglas factor share for the material input which is around 0.6 for the Indian manufacturing sector.[35] Hence, a 1% under-utilization of materials per worker can reduce the output by 0.6%. Similarly, a 1% under-substitution of materials per worker in a time-period lowers the output growth by around 0.6% of its potential growth rate (i.e. growth rate in no restrictions case). As the earlier sections discussed, the average $(\frac{M}{L})$under-utilization for the period between 1973 and 1991 was 24%. It means that the gross output of Indian manufacturing was around 15% below its potential output for almost 20 years. The reforms helped in removing the imported intermediate input distortions and thus faciliated the growth.

3.6.2 Jobless Growth - What is Left Wanting?

But the reforms did not remove the labor market regulations. The reason might be political but it is definitely having an impact on Indian economy.

[35] These equations ignore the effect of pre-reform restrictions on K and L inputs as well as on the TFP.

The estimates show that firms have started oversubstituting capital and materials compared to labor even though it is no longer necessary. Fernandes and Pakes (2008) [36] find underutilization of labor in 2001 which is a consequence of this oversubstitution by Indian manufacturing firms. Figure 3.7 plots indexes of input usage for unit output. Most worrying is the trend in labor used per unit of output, which has gone down by more than 50% in years after the reform. Some of this reduction is due to productivity gains and better technology, but the index of materials used per unit of output is continuously increasing. This points towards reluctance of firms to hire workers due to expected problems with labor laws. Firms are opting to use extra materials and capital to avoid getting stuck with more workers since firms still cannot fire workers. This explains the jobless growth in manufacturing, because growth is coming from oversubstitution of materials and capital. The increase in materials usage can be thought of as a *moving-up in the value chain* of manufacturing, where the firms prefer to buy the intermediate inputs from outside rather than producing them in-house. As the decreasing share and growth rate of unorganized manufacturing output shows, the unskilled workers have even more limited opportunities because the unorganized manufacturing firms are facing competition from the foreign intermediate-input producing firms after the reforms.

Many economists have raised doubts about sustainability of the impressive performance of Indian economy in the long run because of this jobless growth phenomena. The labor laws and labor market regulations will have to be addressed to provide incentives for firms to hire workers. At the very least, the disincentives (implicit costs, future inflexibilities etc.) of hiring workers must be removed.

Even though the growth based on productivity and efficiency improvements is better than the simple input accumulation induced growth, the scope for TFP improvements reduces as the economy moves closer to the production frontier. Indian policy makers need to start thinking about how to move along this frontier by conventional input (labor, capital and human capital) growth. Also missing from the discussion are the output potential and the unemployment rate. The problem of under-utilization of the labor capacity, as measured by unemployment or under-employment of the workforce, should be addressed. A consistent productivity growth ($\frac{Y}{L}$) will reap more rewards if it is accompanied by the increase in L (the labor input). India has to address this issue now, if it wants to convert the so called *population time bomb* to its *demographic advantage* (compared to the developed countries, India has a very young workforce).

3.6.3 Other Possible Explanations

The evidence presented in this paper points towards existence of a relationship between materials underutilization and lower productivity growth. The reforms in 1991 seem to have broken this relationship. But these empirical results are based on Annual Survey of Industries dataset, which covers only the registered manufacturing. Hence the analysis explains only a part of the Indian economic growth surge observed after 1991. Since service sector has contributed significantly to the output growth, the main reason should be found by studying the performance of service sector. Unfortunately, the detailed dataset on capital and labor inputs for service sector is not available.

Even though various studies have found very small contribution of Information Technology in the output growth, the debate is far from settled. Colecchia and Schreyer (2002) [25] find that during second half of the 1990s the contribution of ICT capital in output growth has been between 0.3% to 0.9% per year for nine OECD countries. Jorgenson and Vu (2007) [51] claim that differences in aggregate output per capita can be explained by input per capita and that the contributions of IT investment have increased. But the growth in output of the service sector of India has been really remarkable. The role of telecommunication and internet technologies which triggered the outsourcing boom can not be treated as trivial. A panel data analysis of service sector firms versus other firms (that have no direct gains from telecommunication technologies) can be carried out. But disentangling the technology diffusion from the effect of reforms that enabled service firms to make the required investments and get the foreign clients will be tricky, because the timing of the internet revolution and reforms in India coincide.

This paper tries to provide one explanation for the surge in Indian manufacturing productivity growth and why the productivity growth was slower earlier. Can the same inefficiency mechanisms be applicable to the service sector? Probably not. But it was the manufacturing sector that lagged in TFP performance and hence dragged down the aggregate economic growth in India in 1970s and 1980s. If these mechanisms rising due to licensing and quota system had not been there, there is a chance that Indian manufacturing would have grown at the comparable rates as other Asian economies.

There have been many studies on explaining the slow TFP growth in Indian manufacturing before the reforms. These studies focus either on trade and other restrictions or on labor laws as possible factors. Kotwal, Ramaswami and Wadhwa (2009) [54] provide a nice summary and evaluate many of these explanations. Most of the researchers have tried to exploit the state-wide variation in performance and then posit that the differences in policies are responsible for these differences. Besley and Burgess (2002) [12] and Ahsan and Pages (2007) [64] find that 'pro-worker' policies have a negative effect on productivity and 'pro-employer' policies have a positive effect. Topalova (2004) [73] shows that reduction in trade protectionism led to higher firm level productivity. She finds *no effect* of state-level characteristics such as labor deregulation and financial development.

This paper complements these studies by providing the reason behind the observed relationships between policies and productivity. By relying on the mechanisms that are driven by optimality conditions, the paper does not have to worry about the criticisms from the researchers who question the regressions with policy indicators as explanatory variables for the productivity differences. The paper also reconciles the two set of researches by showing that the labor regulations were affecting the productivity growth in presence of the trade restrictions. Since Topalova (2004) [73] accounts for trade protectionism separately she does not find the effect of labor regulations as observed by Besley and Burgess (2002) [12] and Ahsan and Pages (2007) [64], because the inefficiency mechanisms work only through the interaction of these two policy restrictions.

The role of materials is crucial in the discussion of this paper. But how complementary is material input to the labor input depends on the industry and the production technology. A firm can not make a car without tires and engine and it can not substitute the labor for lack of the intermediate input. But the degree of complementarity varies by the industry. The continuous growth of materials used per unit of output can also mean that firms are moving towards more high-end manufacturing. The negative relationship between TFP growth and employment growth can also be explained by this. Since in any industry there is some *churning* going on, where usually the unproductive firms close down and as a result the overall productivity of the industry improves. If the remaining more productive firms do not hire more workers, the overall employment goes down. In case of Indian manufacturing, the more productive firms may be shying away from hiring because they don't want to get stuck with large number of workers that can never be fired. An alternative explanation could be that these firms are *outsourcing* some of their low-end production to unorganized manufacturing sector. Figure 3.9 shows that the output growth of unorganized sector has gone down in recent years. This combined with the fact that amount of imported materials has been growing significantly (Figure 3.8) points that the registered manufacturing firms might be substituting the materials bought from the unorganized sector by the imported materials. One can use the data on input-output tables to analyze which of these two alternative explanations is valid.

Even with regard to explaining the manufacturing growth in India there is an issue. Since the data is available only for registered manufacturing, the results may not hold for unorganized manufacturing. Ray (2004) [70] estimates that the output for unorganized manufacturing was almost one-fifth of registered manufacturing in 2001 and unorganized manufacturing employed six times as many workers as the registered manufacturing. In general, the incentive mechanisms described in the paper are applicable to unorganized manufacturing firms as well. But the effect of these mechanisms on unorganized firms might be different than on registered manufacturing firms. Kotwal, Ramaswami and Wadhwa (2009) [54] highlight this difference and stress on performing the disaggregated analysis. Their point is valid especially if the objective is poverty reduction, because most of the unskilled workers are employed in the unorganized sector. But lack of data makes such an exercise very difficult.

This paper provides only a part of the explanation for the Indian economic growth surge. A more detailed sectoral analysis, especially using the data that includes service sector firms, would help us learn more about the success story of the Indian economy.

3.7 Conclusions

This paper provides a number of insights regarding economic growth in India. Negative TFP growth before the reforms was caused by forced distortions in intermediate input usage relative to labor due to policies of quota permit and labor laws. The recent jump in TFP growth comes as the result of removal of restrictions on materials and thus firms' factor allocation moving towards the optimal. The role of intermediate input, which has been ignored until now, deserves greater attention given that it is the most important (highest factor share) input in the manufacturing production process.

Interaction of policies combined with high inflation and lower credit access was responsible for manufacturing growth being slower than services growth. One government policy may end up being counter-productive in the presence of another policy. Hence gradualism approach to reforms should be applied with caution to make sure none of the reforms interact adversely with previous reforms or existing policies. Labor market regulations that are supposed to ensure job safety are hurting workers, since firms are shying away from hiring new workers. TFP growth rates being slightly negatively correlated to labor growth rates is interesting and should be explored further. It may be indicative of the structural inefficiencies in the Indian labor market such as resistance to competition, job reservations, or hiring and promotion by loyalty and age rather than skills. Reforming the labor policies seems to be the next logical step in the reform process.

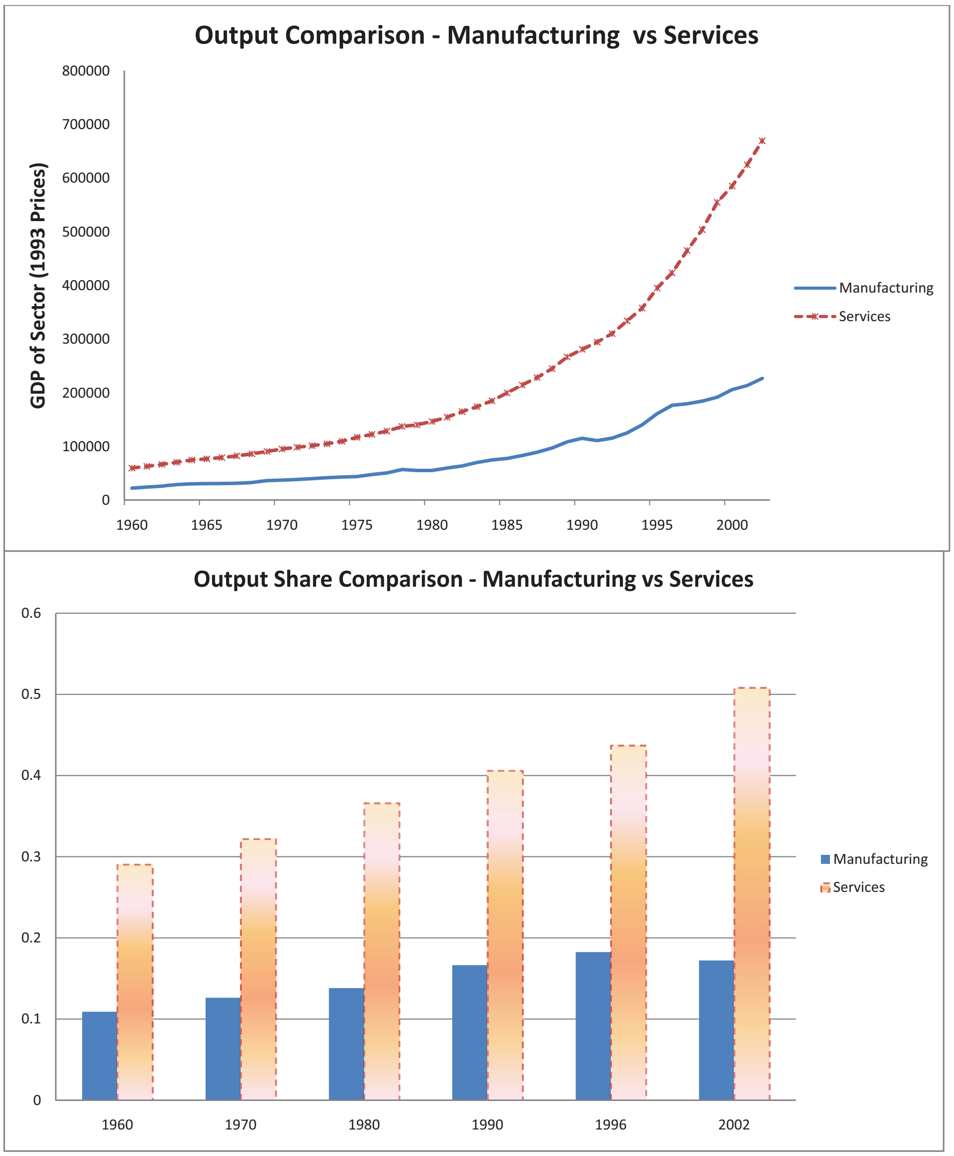


Figure 3.1: Growth Puzzle - Indian Manufacturing vs. Indian Services

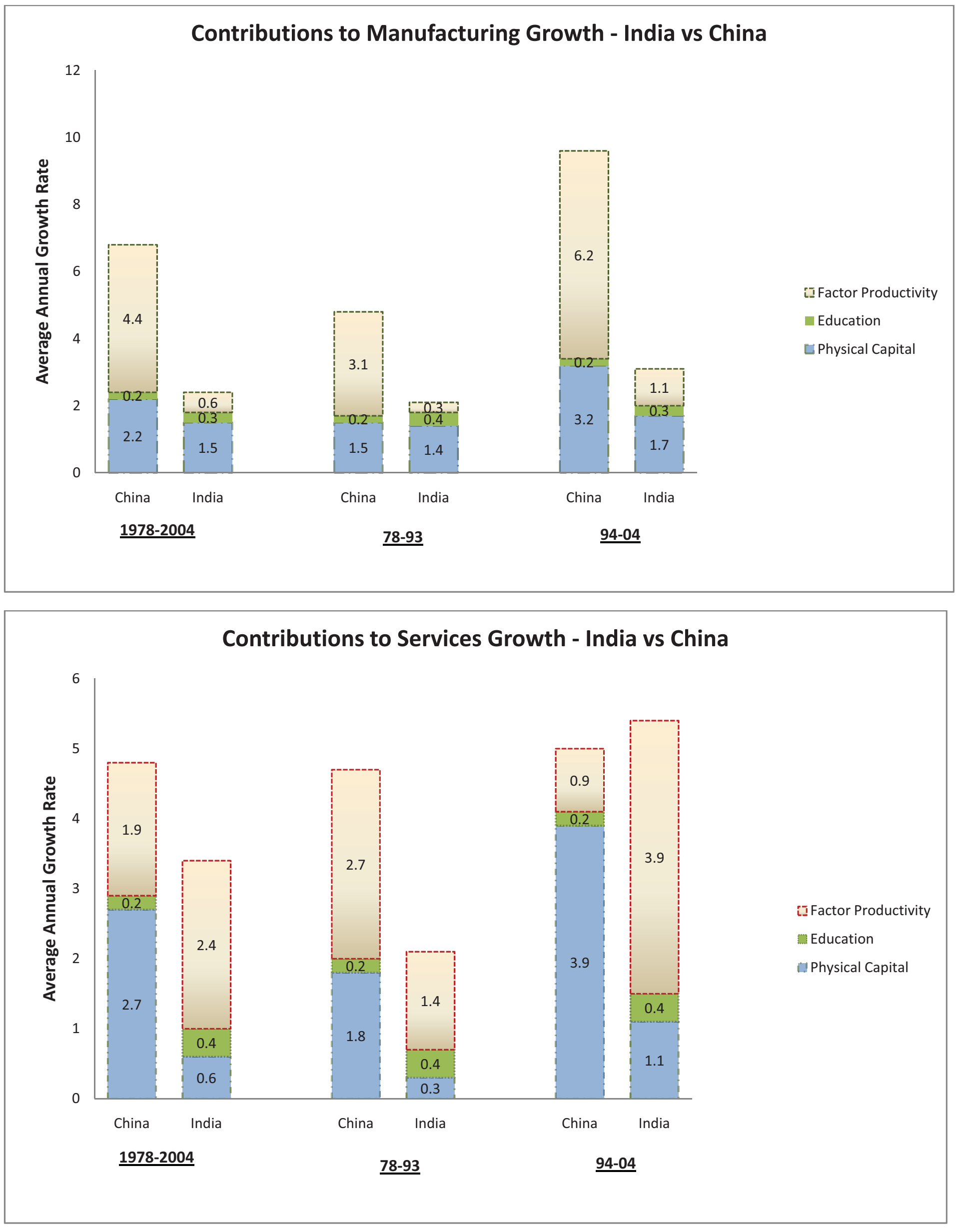


Figure 3.2: Growth Puzzle - Comparing TFP Contribution

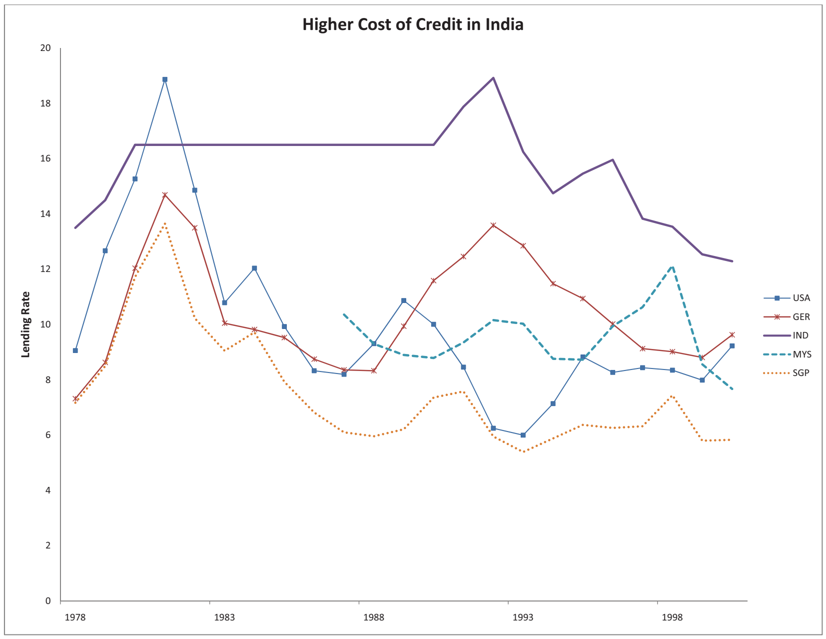


Figure 3.3: Cost of Borrowing - Lending Rates Comparison

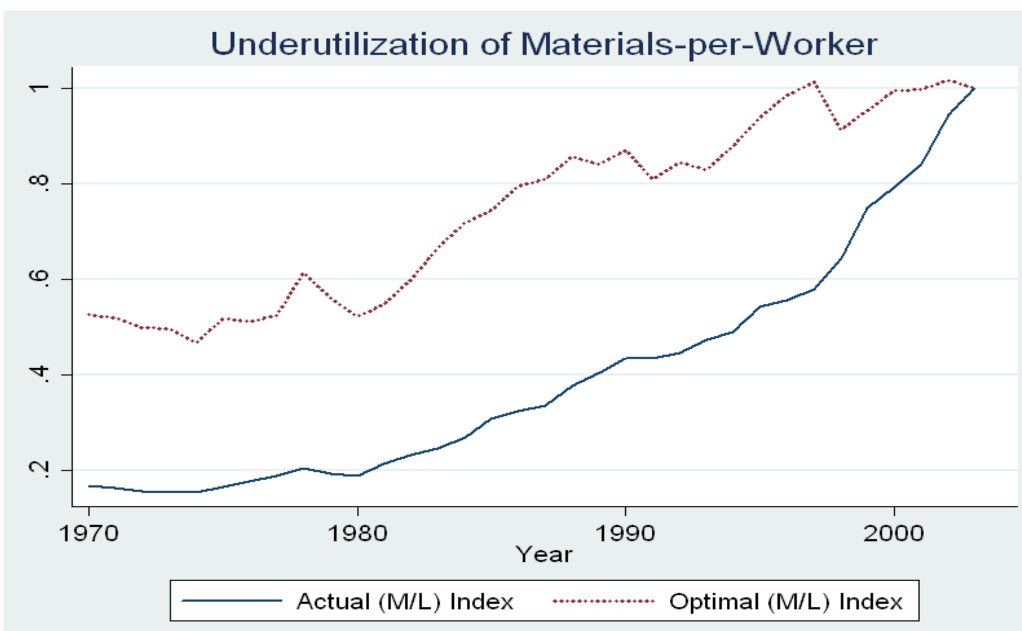


Figure 3.4: Underutilization of Materials Relative to Labor

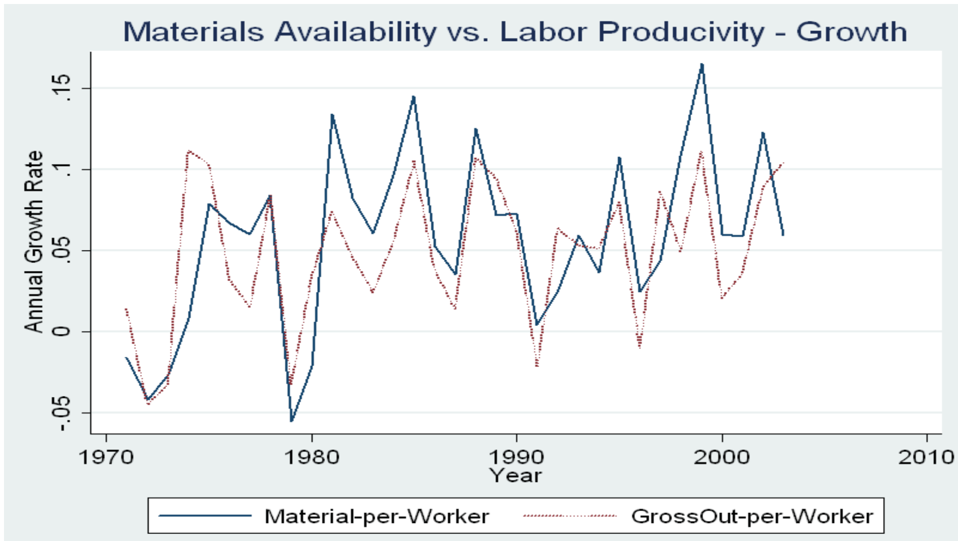


Figure 3.5: (M/L) Growth's Relation to L Prod. Growth - All Industries

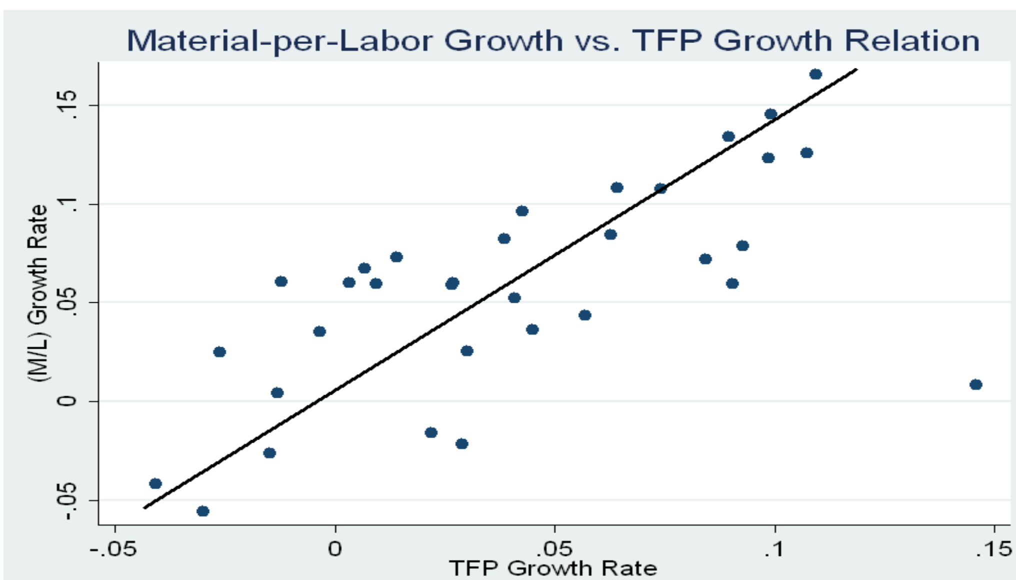


Figure 3.6: (M/L) Growth Causing TFP Growth: 1970-2003 - All Industries

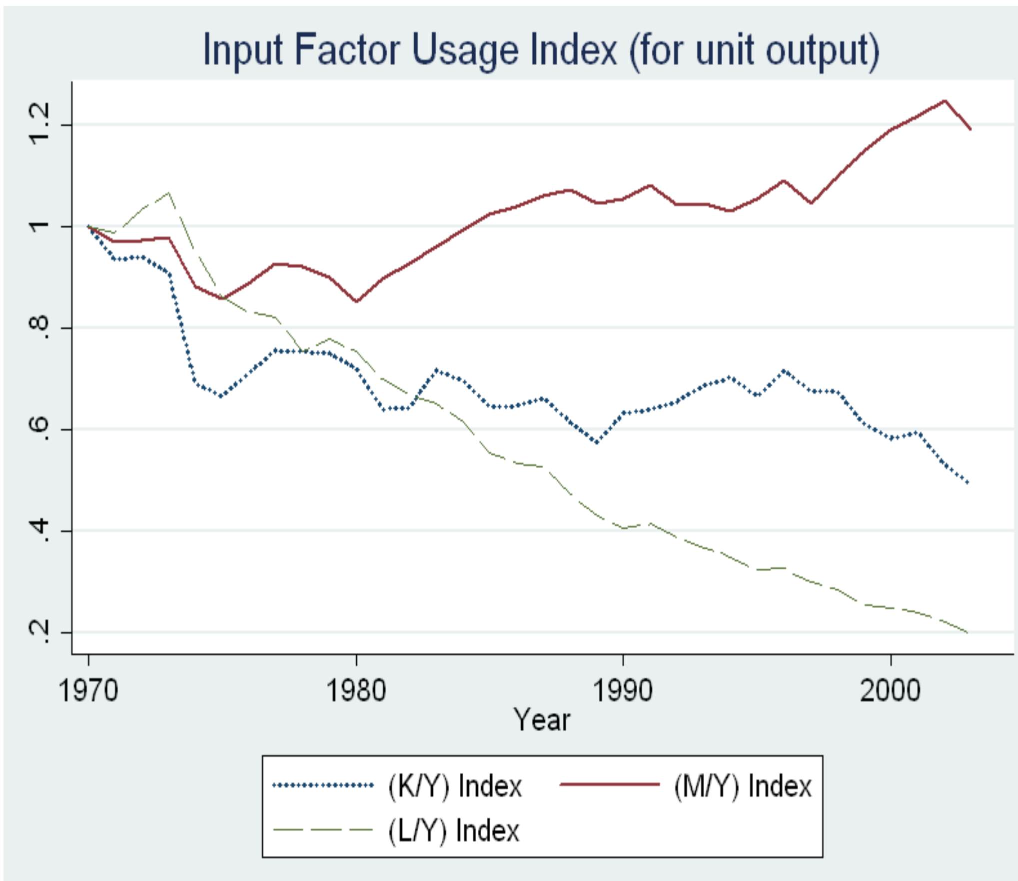
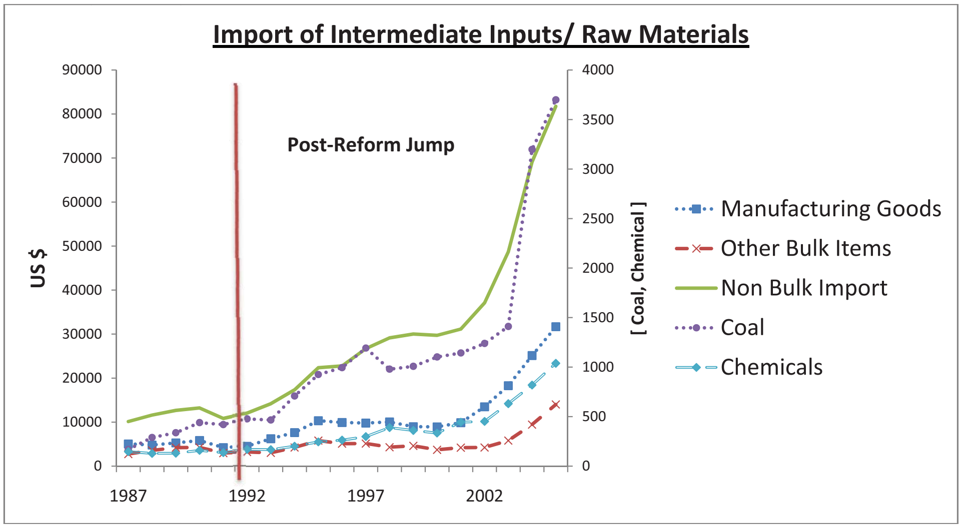


Figure 3.7: Changes in Input Usage for Unit Output



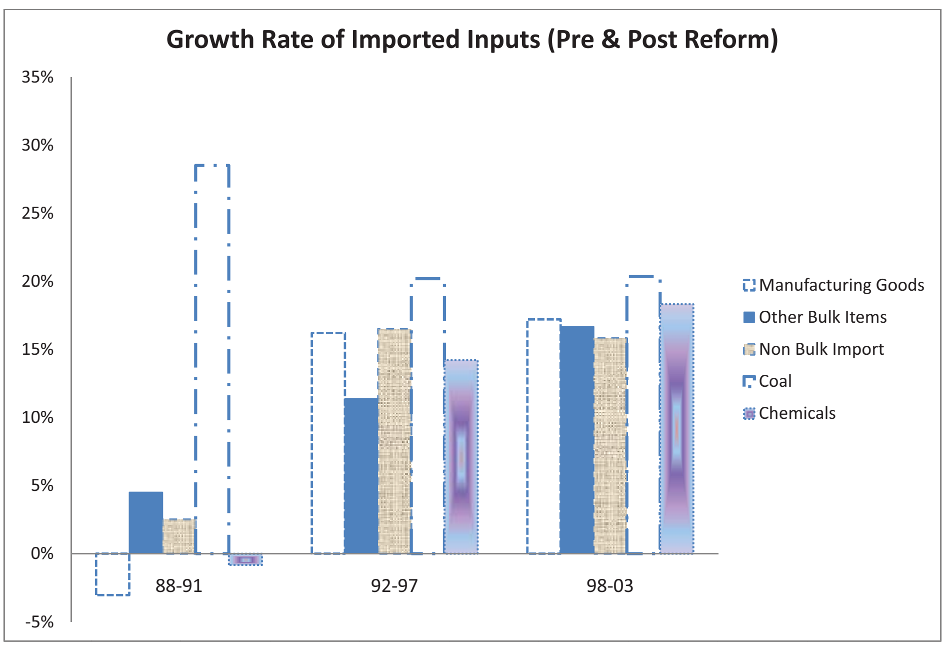
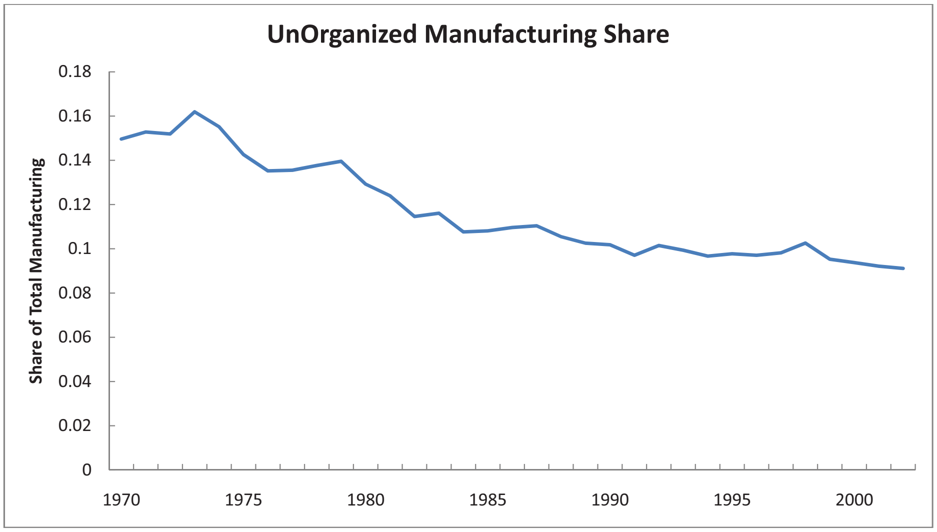


Figure 3.8: Jump in Intermediate Input Imports



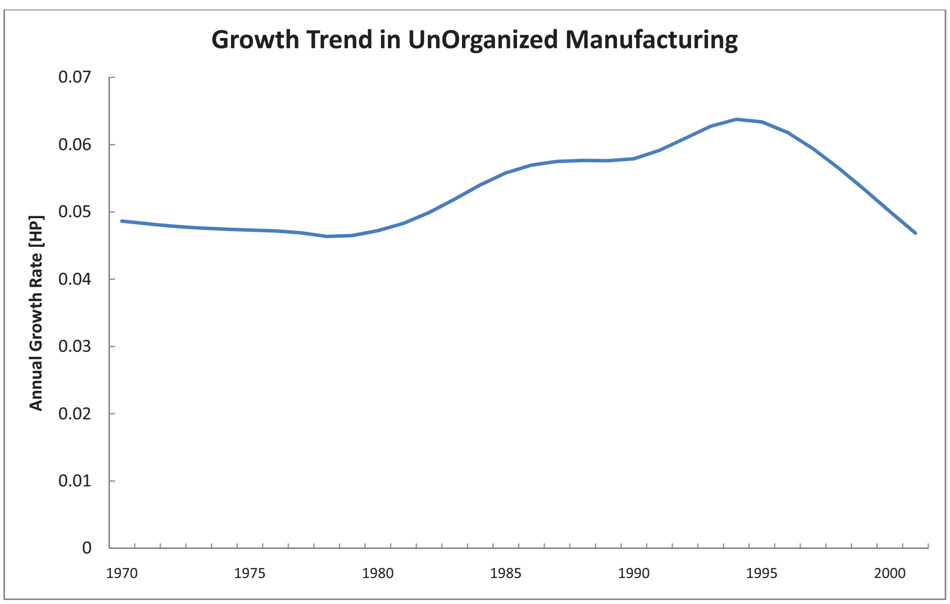


Figure 3.9: Reduced Reliance on UnOrganized Sector after Reforms

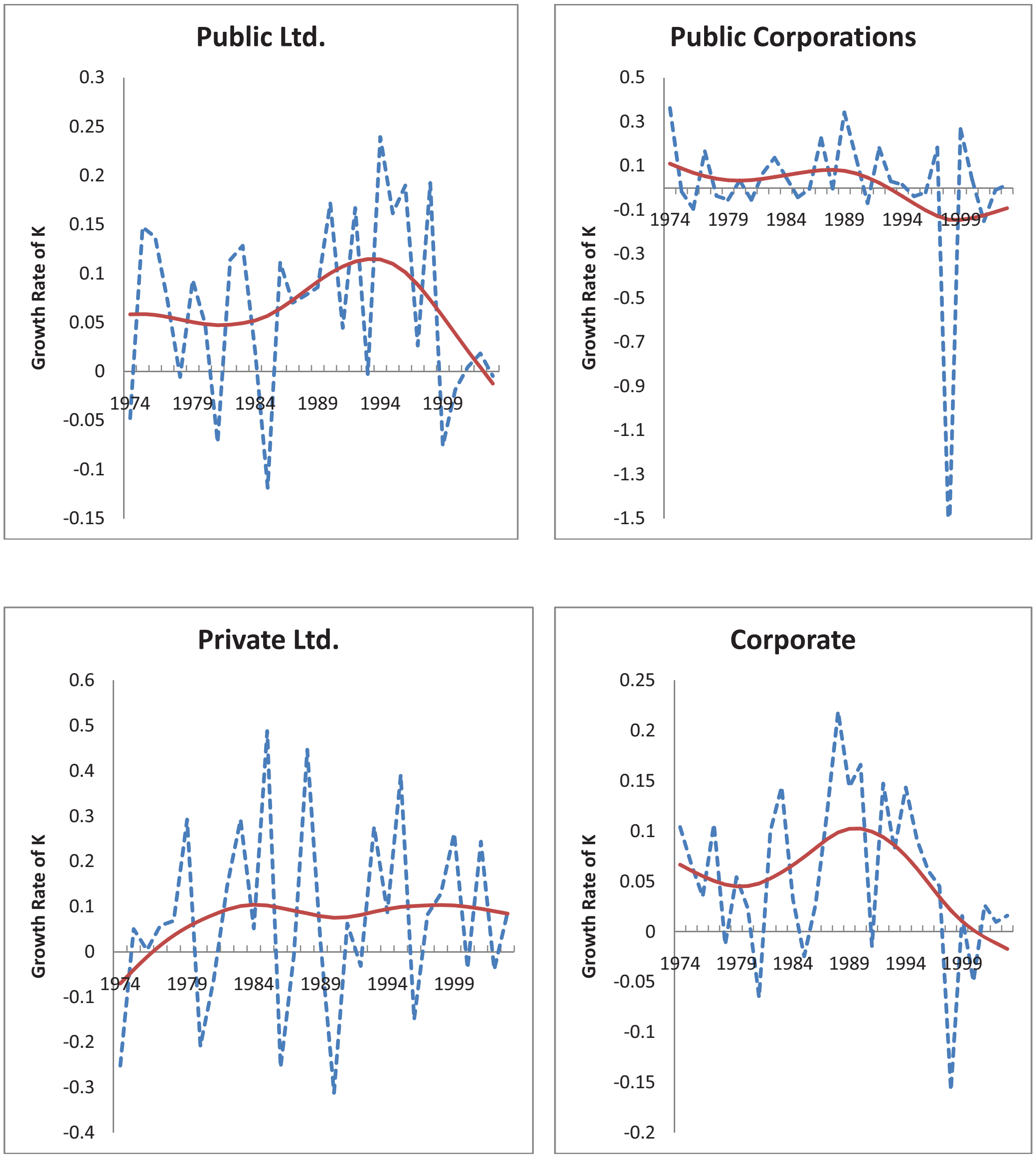
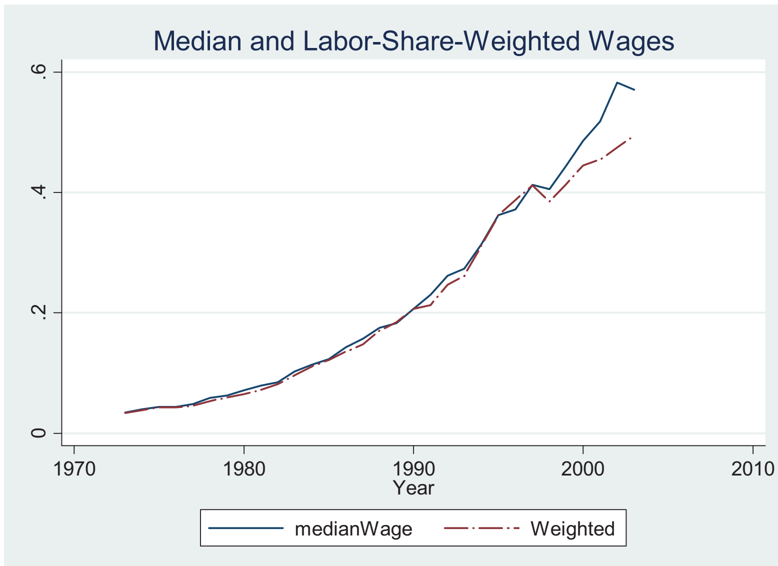


Figure 3.10: Disinvestment from Public Corporations in 1998



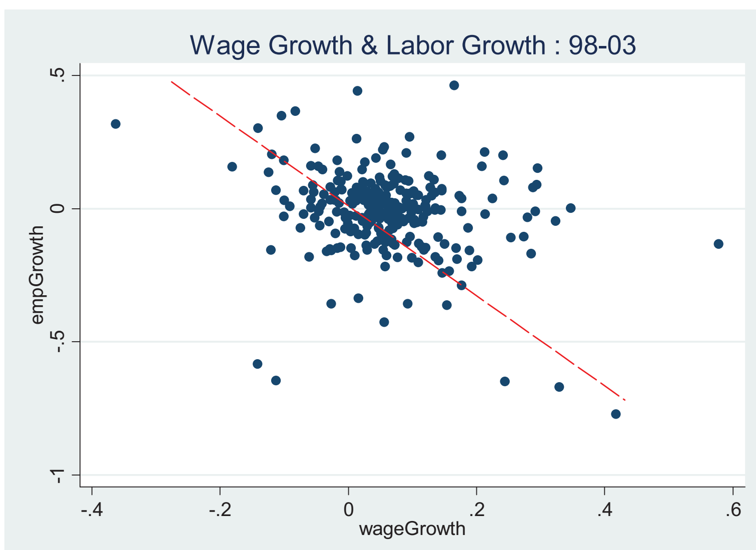


Figure 3.11: Productive Labor Moving out of Manufacturing Sector after Reforms

	Mkt.Cap.(m US$)	($\frac{\textbf{MktCap}}{\textbf{GDP}}$)	($\frac{\textbf{Value Traded}}{\textbf{GDP}}$)
Germany	355073	22.2%	21.4%
Hong Kong	83397	111.5%	46.3%
India	38567	12.2%	6.9%
Korea	110594	43.8%	30.1%
Malaysia	48611	110.4%	24.7%
Singapore	34308	93.6%	55.4%
US	3059434	53.3%	30.5%

Table 3.1: Comparison of Stock Market Indicators in 1990

	Annual Growth Rate				
	1970-2003	**71-80**	**81-90**	**91-97**	**98-03**
Gross Output	6.0%	6.4%	6.6%	7.0%	3.2%
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%
Net Value Added	4.4%	6.4%	4.1%	4.7%	0.9%
Gross Output based measures					
Labor Productivity	4.9%	2.8%	6.2%	4.3%	6.9%
TFP	1.3%	2.4%	2.2%	-0.8%	2.8%
Net Value Added based measures					
Labor Productivity	3.2%	3.0%	3.6%	1.9%	4.3%
TFP	2.3%	4.6%	4.2%	- 2.2%	4.8%

Table 3.2: Period-wise Growth Rates: All Industries

Productivity (Y)	**Distortion (X)**	**Corr.**	**CoVar.**	**Pooled OLS β**
L Prod(GO)	Under-Util. M/L	-.69	-.29	$-.99^{**}$
	Over-Util. K/L	.6	.29	$.74^{**}$
L Prod(NVA)	Under-Util. M/L	-.26	-.15	$-.5^{**}$
	Over-Util. K/L	.29	.19	$.46^{**}$
L Prod G (GO)	Under-Sub. M/L	-.42	-.33	$-.5^{**}$
	Over-Sub. K/L	.18	.2	$.21^{10\%}$
L Prod G (NVA)	Under-Sub. M/L	-.3	-.28	$-.34^{**}$
	Over-Sub. K/L	.21	.25	$.36^{**}$
TFP G (GO/M)	Under-Util. M/L	-.31	-.27	$-.37^{**}$
	Over-Util. K/L	.2	.13	$.23^{NS}$
TFP G (NVA)	Under-Sub. M/L	-.26	-.21	$-.35^{*}$
	Over-Sub. K/L	.17	.13	$.19^{NS}$

Table 3.3: Inefficiency and Productivity Relations: 3-Digit NIC Industries Panel

Productivity (Y)	**Distortion (X)**	**Pooled OLS β**
Real Wage Inflation	Materials Inflation	-5.91** -8.6** (Before 1990) .003^{NS} (After 1990)
L Prod. G (GO)	Materials Inflation	-0.32**
L Prod. G (NVA)	Materials Inflation	-0.39^{NS}
L Prod. (NVA)	L Growth, M Growth	-0.39**, 0.11*
L Prod. G (GO)	L Growth, M Growth	-0.46**, 0.33** -0.73**, 0.7** (After 1990)
TFP G (GO/M)	L Growth, M Growth	-0.22**, 0.20** (After 1990)
L Prod. G (NVA)	L Growth, M Growth	-0.34**, 0.18** -0.43**, 0.48** (After 1990)
TFP G (NVA)	L Growth, M Growth	-0.23**, 0.12** -0.31**, 0.38** (After 1990)

Table 3.4: Prices, Distortions and Productivity: 3-Digit NIC Industries Panel

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Appendix A

Appendix for Chapter 1

List of Data Sources

1. Reserve Bank of India website (http://www.rbi.org.in/scripts/Statistics.aspx) and then select "Handbook of Statistics on Indian Economy".

2. Groningen Growth and Development Centre website (http://www.ggdc.net/index-dseries.html) and then select "Total Economy Database" .

3. Center for International Development, Harvard University website (http://www.cid.harvard.edu/ciddata/ciddata.html) and then select "Barro-Lee Data Set".

4. Central Statistics Organization, Govt. of India - Pocketbook of Indian Statistics.

5. National Account Statistics of India, Economic and Political Weekly Research Foundation.

Other Notes

- Gross Domestic Savings series is available only in current prices. To calculate the growth rate of GDS, the growth rate of $(\frac{GDS}{GDP})^{Current}$ is multiplied by growth rate of $GDP^{Constant}$.

Appendix B

Appendix for Chapter 2

Manufacturing Dataset Creation

In the scheme of ASI, industrial activities in the country are broadly divided into factory and non-factory sectors. The factory sector covers units registered under the Factories Act of 1948. Dictated by the prevailing socio-economic conditions, the Government has been formulating supportive policies for small enterprises, also termed as small-scale sector. And, therefore, small-scale industries (SSIs) are treated as a separate category distinguished from the rest (medium and large scale industries) on the basis of the investment limit on the original value of installed plant and machinery. This, however, does not exclude them from the ASI, the scope of which is defined in terms of the number of workers employed with or without the aid of power.

- **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.
- **Notes 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).