Policy reforms and productivity growth in India's energy intensive industries

Puran Mongia,
Deihi School of Economics,
Delhi 110 007, India

Katja Schumacher &Jayant Sathaye
Lawrence Berkeley National Laboratory,
Environmental Energy Technologies Division,
Energy Analysis Department,
Berkeley CA 94720, USA

Abstract

India had a highly restrictive industrial and trade policy regime until the end of the 1960s. This regime while succeeding to some extent in creating a diversified industrial base introduced gross inefficiencies in many sectors of the economy. Beginning in the early 1970s, Indian economic policies have been marked by deregulation, decontrol and progressive liberalization. In this paper, we assess the impact of policy reforms on total productivity growth in India's energy intensive sectors: aluminum, cement, fertilizer, iron and steel and paper. Assuming a translog specification of a four input (KLEM) production function, we use growth accounting to decompose the growth of output into growth of inputs and a residual representing total productivity growth. We relate changes in productivity indices to changes in technologies, processes and production conditions, which policy reforms helped bring about. A major finding of this paper is that overall productivity growth in these industries was quite low during 1973—1994. However, there were significant differences in productivity growth across industries during this time period. These differences can to a large extent be explained by the nature and timing of policy changes in individual sectors.

Keywords: Policy reform; Productivity growth; Indian manufacturing industries

1. Introduction

The Indian economy has experienced persistent and pervasive energy shortages in recent years. It is widely recognized that the non-availability of energy is a serious obstacle to economic growth. Industrial energy demand accounts for more than 5000 of total energy demand, and is growing at **5%**. (lEA, 1994). There is a growing realization that output expansion based on increasing use of energy and other resources is not sustainable in the long run. This points to the need for studying the efficiency, or the productivity, with which resources are used in the Indian economy. In recent years productivity growth has also been identified as an important factor in reducing US CO_2 emissions (Hogan and Jorgenson, 1991).

Given the coal-dominated primary energy resource base of the Indian economy, environmental, including $C0_2$, considerations provide another rationale to examine productivity growth in India.

In this paper, we explore trends in productivity growth in India's energy intensive industries: aluminum, cement, fertilizers, iron and steel, and paper and also in aggregate manufacturing. Our aim is to focus on the effect of policy reforms on productivity growth. Productivity growth in India's energy intensive industries has been extensively studied.' However, the effect of policy reforms on productivity change has not been adequately explored. In a few cases, where this linkage has been studied, indicators like import penetration ratio or effective rates of protection, representing changes in industrial and trade policies have been related to indices of total factor productivity growth (TFPG) through multiple regression techniques. This requires an assumption that policy changes can be represented by variables, which are continuous in time. We stress that policy changes are discrete events, which are episodic in nature. So are changes in technology and production conditions. Also, the effect of the former on the latter takes place with a lag. Therefore, we judge the effect of policy changes in broadly defined sub-periods. Also, in a recent survey of the literature on productivity growth in Indian industry, Mongia and Sathaye (1998a) found that the estimates of productivity growth by different authors within and across different industries covered a wide range. The range of estimates was so wide that an unambiguous judgment about the nature and extent of productivity growth in Indian industry could not be made. The estimates varied because of differences in methodology, levels of aggregation, sources of data and time periods of study.

This paper is motivated by the need to have comparable estimates for the five industries based on a uniform methodology, a common database and the same study period. It complements a recent paper (Roy *et al.*, 1999) where we used econometric estimates of cost functions to infer magnitude and biases of technical change in these industries. And it builds on Mongia and Sathaye, (1998b) where we used the method of growth accounting to estimate productivity growth and technological change in these industries. Our aim in this paper is to bring out details relevant from a policy point of view that tend to be glossed over in econometric estimates.

A major finding of this study is that differences in productivity growth across industries, and across time for individual industries, can be largely explained by differential impacts of policy reforms. This is due to differences in initial conditions and in structural and institutional factors specific to industries. The plan of this paper is as follows. The next section contains a brief perspective on energy intensive industries. Section 3 outlines the methodology and describes the sources of data. In Section 4, we present estimates of partial and total productivity growth. Section *5* relates these estimates to policy changes in the Indian economy, and Section 6 contains concluding remarks.

2. Energy intensive industries: a perspective

We define energy intensive industries to include those which are characterized by high energy to output ratios. These industries, therefore, account for a large share of total energy consumption in the manufacturing sector relative to their share in output. The five industries are chosen out of 10 identified with total fuel consumption of over Rs. 1 billion and fuel costs out of the total costs of more than 6% (CSO, 1994; Raghuraman, 1989).

The five industries under review occupy an important place in India's strategy of planned economic development where industrialization was considered the engine of growth for the rest of the economy. Iron and steel has always been considered essential to the development of all other industries. Aluminum is an essential input to the power sector, which is a priority sector in the Indian economy. As a versatile non-ferrous metal it has diverse applications beyond the power sector. Its importance is heightened by the fact that the country does not have an adequate resource base for copper while there are abundant reserves of bauxite ore which is the raw material for the manufacture of aluminum. Cement is a major input to construction and therefore its production along with iron and steel is considered an important index of development. The fertilizer sector has played a critical role in the success of India's green revolution, which has ensured much desired self-sufficiency in food. At present, India has a large and diversified fertilizer sector which ranks fourth in the world in terms of production. The paper industry apart from its widespread use in packaging is vital to the country's literacy, education and social development plans.

On the basis of its perceived importance, the Indian government made the development of the iron and steel industry the exclusive responsibility of the state. The remaining four industries were open to private investment, but it was considered essential that the state regulate them. Looking back at the development experience of the last 50 years, one can see the important role these industries have played. Apart from providing the critically needed capital and intermediate goods for other industries, they have been a source of both direct and indirect employment for a large part of the population. At the same time, the development of these industries has become a source of concern because they consume a disproportionately large share of energy in the manufacturing sector, and as a result are a major source of greenhouse gas emissions. Additionally, they have been identified as major sources of local pollution.

In Table 1 we have listed output and energy consumption shares of individual industries relative to aggregate manufacturing. In 1994, energy intensive industries as a group consumed close to 40% of energy while accounting for around 16% of output within the manufacturing sector. The iron and steel industry dominated with over 13% share in energy consumption and around 7% share of output. The iron and steel industry, together with cement and fertilizer, consumed over 31% of total energy. The relative shares reported in this table have changed only marginally during 1973—1994, the period of our study. Table 1 also lists energy intensity as well as elasticity of energy use with respect to output in these industries. Note that even the lowest energy intensity for the fertilizer sector is close to twice that for aggregate manufacturing. The elasticity of energy use with respect to output ranges from a low of 0.82 for fertilizer to a high of 1.32 for aluminum. These point to the likely high increase in demand for energy as output expands in future.

Table 1 Energy intensive industries (EEl): some indicators

	Share in manufacturing output 1994 (%)	Share in manufacturing energy consumption 1994 (%)	Energy intensity of output1994 (%)	Real growth of output[a] 1973—1994 (%)	Real growth of energy use 1973—1994 (%)	Output elasticity 1973—1994
Aluminum	1.1	3.4	19.7	*6.5*	*8.5*	1.32
Cement	2.0	10.5	35.0	8.7	8.8	1.01
Fertilizer	4.1	7.8	12.6	10.6	8.6	0.82
Paper	2.0	*4.5*	*15.1*	6.1	*7.5*	1.23
Iron and steel	7.2	13.4	12.1	*7.5*	6.3	0.85
EEl sub-total	16.4	39.7	15.9	8.8	7.6	0.86
Total manufacturing	100	100	*6.5*	*7.5*	7.1	0.95

[a]Average annual exponential growth.

3. Methodology, coverage and sources of data

We report estimates of partial productivity growth **(PPG)** and total productivity growth (TPG). Partial productivity is defined as the ratio of output to that of a given input. It can be interpreted as the average product of the relevant input. An increase in this ratio over time indicates productivity growth. TPG is defined as the excess of growth of output over the growth of a weighted sum of inputs. It, therefore, reflects the growth in output that cannot be explained by the growth in inputs. We use the method of growth accounting to decompose the growth of output into that of inputs and a residual. The residual is termed as TPG and is associated with learning by doing, better capacity utilization, resource conservation, advance in technology and economies of size and scale. It is significantly influenced by policies that affect research and development expenditure and facilitate incorporation of better processes or technologies in production. A distinction can be made between pure technical progress, identified with an upward shift in the production function, and changes in resource use efficiency attributed to miscellaneous factors. It is not always possible to categorize these factors, and in the present paper we ignore that distinction.

Productivity growth estimates are based on an underlying production function with one output *(Y)* and four inputs, capital *(K)*, labor *(L)*, energy *(F)* and materials *(M)*. We estimate a gross output form of a production function because a value-added form is not separable. Consequently, our estimates of total productivity growth are not strictly comparable with estimates of total factor productivity arrived at by the use of the two input production function. We use a Translog measure of productivity growth. This measure, which is Tornquist's discrete continuous Divisia index, is given by

$$g_{t+1} = \ln\left[\frac{Y_{t+1}}{Y_t}\right] - \sum_j \left[\left(\frac{s^j_{t+1} + s^j_t}{2}\right)\ln\left(\frac{I^j_{t+1}}{I^j_t}\right)\right],$$

where, t indicates time period, g_{t+1} indicates productivity growth in period t + 1 over period t, Y is a measure of output, S^j indicates share of *j*th input, I^j is the value of *j*th input.

An index can be formed from above by writing $G_{t+1}=G_t\exp(g_t+_1)$, and assuming $G_0 = 1$.

The study covers the period 1973~1994.2 In addition, the results are presented for two sub-periods, 1973—198 1 and 1981—1994. In the subsequent part of this paper we refer to these as the first sub-period and the second sub-period. The choice of the initial and the final year was dictated solely by availability of comparable published data. The choice of sub-periods was guided by our desire to highlight the impact of policy changes on productivity growth.

The data on inputs and output at the 3-digit level of aggregation were obtained from the Central Statistical Organisation (CSO). The nominal values were converted to real magnitudes by deflating them with appropriate wholesale price indices (WPI) which were obtained from the Office of Economic Advisor and from Chandhok (1990). For each industry, factor shares used as weights for different inputs were estimated in the following manner. The share of labor was obtained as the ratio of total emoluments and total value of output. Shares of energy and materials were derived as the ratio of the value of input to the value of total output. The capital share was then obtained as a residual assuming that the factor shares would add up to unity. For additional details on the construction of these variables see Mongia and Sathaye (1998b).

4. Results

Estimates of TPG for the period 1973—1994 and selected sub-periods are presented in Table 2.[3] movement of productivity indices over time is shown in Fig. 1. Over the whole time period, productivity growth was significant only in one of the five industries, the fertilizer industry (2.08% p.a.). It was positive but low in aluminum (0.61% p.a.), and in cement (0.58% p.a.). It declined in iron and steel (-0.91% p.a.) and paper (-0.88% p.a.). TPG for total manufacturing was also low at 0.2% p.a.

These results are clearly disappointing from a resource use point of view. As seen in Table 2, a common observation is that the growth of the sum of inputs dominates over productivity growth of selected industries in accounting for sectoral output. For the only well-performing sector, fertilizer, productivity growth contributed only 20% to output growth. The rest over 80% was the result of input growth. For aluminum and cement, productivity growth made smaller contributions at less than 10 and 7%, respectively. For iron and steel and paper, significant negative TPG implied that input growth far exceeded output growth (12 and 14%, respectively) indicating wasteful use of resources. For aggregate manufacturing almost the entire output growth is explained by input growth (around 97%).

Table 2. Sources of growth in sectoral output[4]

Sector/year	Rate of output growth	Total input	Productivity growth	Sector/year	Rate of output growth	Total input	Productivity growth
Aluminum				*Iron and steel*			
1973–1994	6.46	5.84	0.61	1973–1994	7.45	8.36	− 0.91
1973–1981	2.17	5.13	− 2.96	1973–1981	10.66	10.80	− 0.14
1981–1994	9.10	6.28	2.81	1981–1994	5.47	6.85	− 1.38
Cement				*Paper*			
1973–1994	8.67	8.09	0.58	1973–1994	6.11	6.99	− 0.88
1973–1981	4.18	4.42	− 0.24	1973–1981	6.39	7.05	− 0.66
1981–1994	11.43	10.35	1.09	1981–1994	5.94	6.95	− 1.01
Fertilizer				*Agg manufacturing*			
1973–1994	10.55	8.47	2.08	1973–1994	7.51	7.31	0.20
1973–1981	12.39	10.48	1.91	1973–1981	8.02	5.80	2.22
1981–1994	9.42	7.23	2.19	1981–1994	7.20	8.24	− 1.04

[a]Average annual exponential growth in percentage values.

As Fig. 1 shows, productivity growth was not uniform over time. Instead, the productivity indices show significant fluctuations and marked departures from a trend.

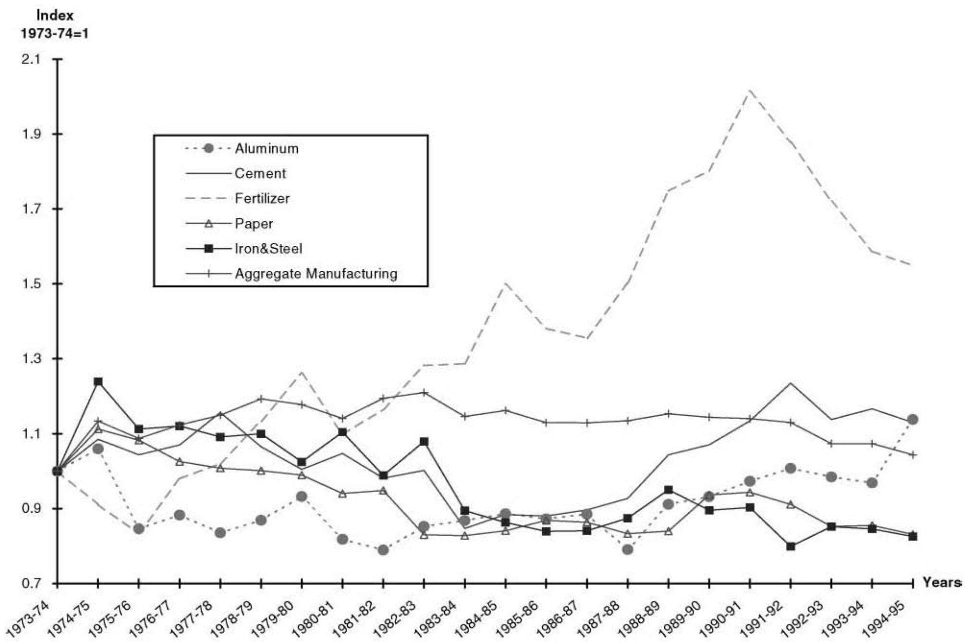

Fig. 1. Translog index of total productivity (1973–1994).

Table 3. Partial productivity growth (growth in VO/input factor)[a]

Sector/year	Capital	Labor	Energy	Material
Aluminum				
1973—1994	— 0.30	3.26	— 2.08	0.56
1973—198 1	— 0.62	— 1.83	— 9.28	— 2.37
1981—1994	— 0.11	6.40	2.36	2.37
Cement				
1973—1994	— 1.78	5.77	— 0.13	1.92
1973—198 1	— 2.58	1.48	1.22	— 0.11
198 1—1994	— 1.29	8.42	— 0.96	3.17
Fertilizer				

1973—1994	3.97	7.23	1.93	0.70
1973—198 1	5.19	7.94	— 0.30	— 0.02
198 1—1994	3.22	6.80	3.30	1.14
Iron and steel				
1973—1994	— 2.31	5.47	1.11	— 1.39
1973—198 1	— 0.07	6.31	3.54	— 2.06
198 1—1994	— 3.69	4.94	— 0.39	— 0.98
Paper				
1973—1994	— 4.27	3.33	— 1.39	0.16
1973—1981	— 3.01	1.69	— 1.31	0.25
198 1—1994	— 5.05	4.34	— 1.44	0.10
Agg manufacturing				
1973—1994	— 0.72	5.34	0.40	— 0.12
1973—198 1	2.18	4.23	1.62	2.03
198 1—1994	— 2.51	6.03	— 0.34	— 1.45

[a]Average annual exponential growth in percentage values.

For all sectors, except for fertilizer and aggregate manufacturing, the pre-liberalization period, 1973—1981, is characterized by a negative productivity trend. The post-liberalization period, 198 1—1994, on the other hand shows significant improvement for a few sectors.

Partial productivity growth estimates are reported in Table 3. Productivity of capital declined in all industries except the fertilizer industry. In contrast, labor productivity shows remarkable growth in all industries. This could largely be attributed to an increase in the use of capital and energy per head and reflects substitution of capital and energy for labor in production processes at the early stage of development. Material productivity grew significantly only in the cement industry. It declined steeply in the iron and steel and was positive but low in the other three industries.

Energy productivity shows mixed trends. It declined in aluminum, cement and paper and increased in the other two industries. Between the two sub-periods there was a noticeable change in the growth rate of energy productivity. There was a significant improvement in aluminum and fertilizers and a moderate to significant decline in other industries.

5. Policy reforms and productivity growth

India began with a highly restrictive industrial and trade policy regime in the 1950s. In a program that laid emphasis on heavy and basic industries, the public sector was given a dominant right in the production of major capital and intermediate goods. Outside the public sector, the establishment of industrial units was regulated by a strict and detailed licensing system. Prices and distribution of major commodities were subject to controls.

Under this policy regime India did succeed in creating a large and diversified industrial base. But, excessive
controls and lack of internal and external competition resulted in gross inefficiencies and high costs. As a result, the high growth rates experienced in the 1950s and 1960s could not be sustained.

In the 1970s, the government took several steps towards reducing the state’s control over the economy. These included allowing large industrial houses and even foreign companies to invest in important segments of Indian industry from which they had hitherto been excluded. In the 1980s, the government encouraged large volumes of production with special emphasis on modernization, expansion and optimum utilization of installed capacity. Several categories of industries were delicensed. Trade policy was liberalized to allow for easier import of capital and intermediate goods, and to spur technological advancement in the capital goods industry through competition with foreign producers. The year 1991 saw the government announcing far-reaching economic reforms.

In brief, the period 1973—1994 was marked by policy changes that were aimed at deregulation, decontrol and progressive liberalization of the economy. The actual implementation of these policy changes was sector specific and differed in time and extent. In addition, industries responded to policy changes with varying time lags. In many cases the stimuli provided by different policies were mutually contradictory. Therefore, the effect of changes in policies on productivity was not uniform across industries.

In the following, we describe policy changes and other developments which had a bearing on productivity growth in different industries. A brief overview of these along with the time frame on which they were implemented is presented in Table 4. Our aim is to relate changes in policies to observable changes in technologies, processes and production conditions in different industries. In this way, we try to explain the contrasting experience of rapid productivity growth for the fertilizer industry, positive but low growth for cement and aluminum and negative growth for iron and steel and paper.[4]

Table 4 Industry-specific policy and structural changes

Sector	Policy
Aluminum	Highly regulated until the late 1980s Decontrol in early 1989
Cement	Price and distribution control until 1982 Partial decontrol introduced in 1982 In early 1989 withdrawal of all price and distribution controls
Fertilizer	Introduction of retention price system 1977—1979 Distribution control and retention price system until 1991 Dual pricing policy introduced in 1991 Gradual removal of price and distribution control since mid-1992
Iron and steel	Dual price system from 1972 on Since 1992 price and distribution completely decontrolled for private sector units Distribution to priority sectors still controlled for other units
Paper	Severe paper shortage in the early 1970s, increased concession of licenses to small scale producers Price and distribution control since 1974, special exemption for agro-residue and wastepaper based production Removal of price and distribution control for several kinds of paper since 1987
Aggregate manufacturing	Pre-liberalization period ***(—*** 1981) Early liberalization period (1981—1985) Liberalization period (1985—1991) Globalization period (1991—present)

5.1. Aluminum

The low overall productivity growth in the aluminum industry reflects the absence of any major technological improvement. Even world-wide there have been no significant break throughs. The Bayer—Hall—Heroult process continues to be in use since its inception in 1886 (TERI, 1996). For the Indian aluminum industry, the problem was exacerbated by the institutional set up of the industry and the policy regime under which it operated. The industry grew in a highly controlled environment with a large share of the public sector in the installed productive capacity. The creation of new and the expansion of existing capacity was subject to licensing. Throughout the 1970s, the industry was required to supply specified quantities of electric-grade aluminum to the electric utility companies (state electricity boards) at controlled prices. These prices, even though revised periodically, did not adequately compensate for the industry's cost increases. This led to erosion of profitability and a lack of incentive for modernization and upgradation. These in turn were responsible for low capacity utilization.

Prices and distribution were decontrolled in 1989. This was followed by a general re-orientation of policies, which helped bring in larger investment and a significant increase in output. A large part of output growth came from total productivity growth, which increased from— 2.96% pa. in the first sub-period to + 2.81% p.a. in the second. There was an increase in productivity of all factors but especially of energy. The latter which had declined at the rate of — 9.28% in the first sub-period registered an increase to 2.36% p.a. in the second sub-period.
A significantly higher output was achieved through better overall capacity utilization. The latter in turn was made possible by more regular electricity supply through captive generation at the plant level. The regular supply enabled continuous operation of aluminum smelters at high current intensity, which helped to lower specific energy consumption (BICP, 1988). At the same time, the introduction of a large state-of-the-art aluminum smelter by the National Aluminum Company in the late 1980s dramatically increased aluminum output while significantly lowering the capital to output and energy to output ratios.

5.2. Cement

The cement industry experienced low productivity growth (0.58% p.a.) for the period 1973—1994. For the initial years, this could be attributed to the controlled environment in which it operated. In the subsequent years, when it was decontrolled, some of the potential benefits were negated by a demand recession.

Prior to 1982, capacity and production in the industry were subject to licensing. In addition, the government strictly controlled prices and distribution of cement. These controls were truly rigorous. Each tonne of cement, which was produced, was in principle deemed to have been acquired by the government first. It was subsequently released to specific categories of consumers at fixed prices. This had the effect of restricting the flow of investment into the industry. Consequently, productive capacity remained restricted even in the face of persistent excess demand. Also, there was little incentive to undertake modernization of existing plants which, therefore, functioned inefficiently and below capacity.

The industry was decontrolled in two phases in 1982 and 1989 and finally delicensed in 1991. The effect of decontrol was immediate and dramatic. As prices rose, the industry became more profitable relative to other industries. Both new and existing firms undertook investment leading to an expansion of capacity and output. This led to an increase in growth of output from 4.2 to 11.4% pa. between the two sub-periods.

The effect of policy reforms on productivity growth is obvious in this industry. In the first sub-period, total productivity declined at 0.24% pa. This was primarily due to a decline in the productivity of capital and material inputs. The former was caused by underutilization of capacity and the latter due to inefficient functioning of plants. In contrast, in the second sub-period total productivity grew at the rate of 1.09% pa., brought about by an increase in productivity of capital and materials. The growth of output and productivity would have been even higher if overall economic activity had not slowed down during 1991—1994. This becomes clear when we consider that for a brief period 1985—1991 productivity growth was as high as 5.64 % p.a.

Improvements in TPG can be directly attributed to changes in technology and production conditions. Two developments are noteworthy. First, almost all new capacity was based on the more efficient dry kiln process which consumes almost *50%* less heat and 10% less electricity than the older wet process. It is also more than twice as efficient in material processing. At the same time, many old plants were modernized and converted from the wet to the dry process. Second, new plants were, on average, substantially larger than existing plants. They, therefore, brought in significant size and scale economies.

5.3. Fertilizer

The fertilizer industry shows remarkable growth during the period 1973—1994. Its TPG of 2.08 % p.a. contributed more than 20 % to the output growth of *10.55 %* pa. The policy experience of the fertilizer industry contrasts markedly with that of other industries. For example, while in the aluminum and cement industries, output expansion was brought about by a movement from a situation of rigid controls to a situation of free markets, in fertilizer it was state patronage in the form of subsidies which encouraged expansion. Fertilizer policy in India has been integral to the policy of green revolution. Under this policy, the government encouraged the consumption of fertilizer in agriculture and also actively aided the growth of the industry. When in the 1960s private investment was not forthcoming, the government set up several plants in the public sector. Prices and distribution of fertilizer were controlled and a freight equalization scheme ensured fertilizer availability at roughly the same price at different locations in the country. Consequently, even in the first sub-period, i.e., before significant economy wide policy changes took place, output was growing fairly rapidly. TPG was high with a significant contribution coming from growth in capital productivity.

A policy that contributed profoundly to the rapid growth of the industry was the, so-called, retention price scheme (RPS). Under this scheme, the farmgate price of fertilizer was kept low while the industry was paid a higher price to ensure profitability. The price was fixed separately for each individual fertilizer plant and was designed to ensure a post-tax return of 12 % on net worth, apart from covering cost of production. The difference between the farmgate price and what was paid to the industry was met through a subsidy, which came out of the government budget. Under the influence of this scheme, which came into effect in 1977, there was a massive expansion of the industry in the 1980s. Along with the expansion of output there was a step up in TPG from 1.91 % p.a. in the first period to 2.1900 p.a. in the second. Higher TPG was made possible by a significant increase in the productivity of capital and energy. While better utilization of existing capacity contributed to the increased productivity growth, it was the change in the technology that made the vital difference. During 1973—198 1, expansion of the capacity was predominantly in terms of plants based on naphtha, coal and fuel oil. In contrast the capacity which came on stream during 198 1—1994 was based on natural gas as the feedstock. Natural-gas-based plants are known to be superior in terms of energy efficiency (FAI, 1992). Also, the new plants were of significantly larger capacity and allowed firms to reap economies of scale.

5.4. Iron and steel

The iron and steel industry witnessed negative total productivity growth (— 0.91 % pa.) during the period of our study. A major reason for this was technological obsolescence. Until quite recently, India employed technologies which had long been phased out in other countries. This phenomenon can to a large extent be attributed to the organizational structure of the industry. The iron and steel industry in India grew with a dominating presence of the public sector. Currently, steel making capacity consists of seven integrated steel plants (ISPs) and several hundred mini-steel plants (MSPs). The latter produce steel through electric arc furnaces and account for approximately 30% of output. Of the seven ISPs, six are in the public sector.

Unlike their counterparts in the private sector, public sector units were required to meet a variety of vaguely defined social objectives like promoting regional growth and employment. They were also obliged to cater to special categories of consumers on the basis of their perceived importance to the economy. Until the end of the 1970s, the emphasis was on maximizing physical steel output, without necessarily due regard to profitability. The government controlled prices and distribution of steel produced by ISPs. Prices were fixed on ad-hoc basis and were often unrelated to the cost of production. These plants therefore incurred huge losses for a prolonged period of time. There was consequently little surplus for proper maintenance of plant and equipment much less for modernization. In contrast with other industries, investment required for modernization in the steel industry was very large. The decision-making process in the public sector was a long drawn one and spread over many departments and ministries of the government, which prevented timely action. This fact combined with scarcity of resources resulted in a situation where there was tinkering on the margin rather than wholesale replacement of plant and equipment when they became obsolete. Over time, due to deterioration in the quality of coal and other materials, process imbalances appeared which could not be handled by existing technologies. This led to inevitable break-downs and consequent loss of output. Even though capacity expanded rapidly during the 1960s and 1970s, this growth was not matched by productivity growth. Consequently, output growth of 10.6600 pa. in the first sub-period was accompanied by negative productivity growth (— 0.14 % pa.).

Economic reforms did not succeed in reversing the negative trend in TPG. During the second sub-period, as the growth of output slowed, productivity declined at a steeper rate (— 1.3800 p.a.). There was a decline in the productivity of all factors but especially of energy and capital. Both were attributable to a decline in capacity utilization in the public sector units. This was in turn partly due to infrastructural problems and partly due to a loss of market share to mini steel plants. The setting up of mini steel plants had been permitted in the 1970s even though according to the original industrial policy resolution additional capacity could be created only in the public sector. Mini steel plants were allowed with the ostensible purpose of supplying special steels which were in short supply in the 1970s. Mini steel plants, however, diverted their capacity to producing mild steels. Since price controls did not apply to them strictly, these units prospered at the expense of the ISPs. In the Indian context, the electric arc furnace technology, on which these units are based, is less efficient than the blast furnace technology for producing mild steel. Not only is the cost of production associated with it higher, but it also uses very high amounts of power (BICP, 1992).

After 1983, ISPs were allowed to increase prices for some categories of steel to cover costs and to generate profits. Higher prices enabled them to realize windfall profits due to prevailing shortages, which had been worsened by import controls. These profits were, however, temporary and got competed away because of rapid build up of the private sector capacity. The steel sector was decontrolled in 1992. This coupled with changes in trade policy that allowed more liberal imports, led to the closure of many units in the secondary sector. This significantly brought down rates of growth of output and productivity in the later part of our study period.

5.5. Paper

The paper industry too witnessed a decline in productivity for almost the entire period of our study. Significant declining trends in the capital and energy productivity were mainly responsible for the TPG rate of — 0.88 % p.a. As in the iron and steel industry, technological obsolescence and underutilization of capacity were the main reasons for a decline in productivity.

The development of the paper industry in India took place primarily in the private sector. However, the creation and expansion of productive capacity were subject to licensing which, among other things, emphasized the interests of small producers and of regional dispersion. The government controlled the distribution of paper, and large mills were required to supply a certain percentage of their total production at fixed prices. Controls had the expected restricting impact on output growth and by the 1970s there were severe paper shortages. The government took several steps to alleviate these shortages. These included allowing large industrial houses, which had been barred to protect the interests of small producers, to invest in the industry. However, by the mid-1970s, severe shortage of forest-based raw materials had emerged leading to widespread underutilization of capacity.

In order to mitigate the impact of raw material shortages the government extended a variety of fiscal incentives to firms that used non-conventional raw materials, and also exempted them from licensing. In particular, the government allowed small regionally dispersed mills to be set up to use non-conventional raw materials. Further to reduce the gestation lags these units were allowed to be set up with imported second-hand machinery. Even though licensing norms were relaxed, controls on prices and distribution were kept in place. This combined with infrastructural bottlenecks and inadequate supply of coal and power exacerbated the problem of capacity utilization. In the late 1970s, average capacity utilization had come down to 62 % compared to an average of 85% in the late 1960s. The resulting decline in the productivity of capital and of energy led to a decline in TPG (— 0.66 % pa.) during 1973—1981.

In the mid-1980s, barring a few exceptions, the government removed the paper industry from the purview of licensing. It also removed controls on production and distribution and laid great emphasis on technological improvement and cost reductions. However, many of these measures came too late given the situation in the industry. They, therefore, failed to improve productivity growth.

By the mid-1980s, many large mills were more than *25* years old. Machines and equipment needed constant repair and replacement, which was a big problem in spite of the fact that there was adequate domestic capacity in the manufacturing of machinery for the paper industry. This was partly because designs adopted by domestic manufacturers were obsolete and did not adequately cater to the changing needs of the industry. Smaller paper mills suffered from obsolescence but for a different reason. Being second-hand, much of their equipment was already out of date when imported and degraded fast, thus raising the cost of production. (DGTD, 1987).

Major economic policy changes in the 1990s opened up the industry to substantial international competition. The government allowed more liberal imports of newsprint which affected capacity utilization adversely. Even though the government allowed free import of raw materials, the high cost structure of the industry rendered it incapable of facing competition, leading to widespread closure of units. Not surprisingly therefore productivity declined at a steeper rate in the second sub-period, 1981—1994.

6. Concluding remarks

Using the technique of growth accounting we estimated total productivity growth (TPG) for five energy intensive industries in India. Our results show that total productivity growth in these industries during the period 1973—1994 was insignificant, although productivity growth varied across industries. It was significantly positive in the fertilizer industry, positive but low in aluminum and cement, and negative for iron and steel and paper industry. Productivity growth was not uniform over time either. The partial productivity growth of capital and energy appear to be significant determinants of total productivity growth. These in turn were crucially affected by capacity utilization. The analysis of results for two sub-periods, 1973—1981 and 1981—1994, shows that changes in technologies and production conditions triggered or induced by policy reforms helped increase productivity growth significantly in the cement and the fertilizer industry. Policy reforms worked by allowing existing capacity to be used more fully, by allowing additional capacity to be created at a larger or more economic scale, by removing constraints on raw material availability and by allowing access to better technologies through imports of plants and equipment. The effect of policy changes was less significant in the case of aluminum because of lumpiness of investment and because of the inherent nature of the technology. However, the removal of market constraints and the addition of a modern plant did raise the growth rate in the second sub-period significantly. Productivity growth was adversely affected in the case of iron and steel and paper where due to lack of a clear long-term perspective, the positive effects of policy reforms were overwhelmed by institutional and market conditions, at least temporarily. Overall, policy reforms did not go far enough to significantly affect productivity growth in India's energy intensive manufacturing sectors. This is the challenge policy-makers face in the future.

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Footnotes

[1] See Krishna (1987) for a survey of the literature.
[2] Years are financial years. Thus, 1973 indicates a financial year running from 1 April 1973 to 31 March 1974.
[3] The reported growth rates are annual average exponential growth rates of final year values over the initial year values for the relevant period and sub-periods.
[4] 1n this paper we focus on major developments only. For details of specific processes and technologies see Schumacher and Sathaye (1999a, b).

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