AN ANALYSIS ON HIGH TECHNOLOGY INDUSTRIES IN INDIA

SUBMITTED BY

D.SUGANYA

(12PEC015)

A DISSERTATION SUBMITTED TO THE

AVINASHILINGAM INSTITUTE FOR HOME SCIENCE AND

HIGHER EDUCATION FOR WOMEN, UNIVERSITY

COIMBATORE-641 043

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN ECONOMICS

MARCH 2014

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CERTIFIED AS BONAFIDE RESEARCH WORK

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INTRODUCTION

I. INTRODUCTION

During the last decade, major developing countries including India began to integrate much more with the global economy. The countries that are aggressively integrating have grown significantly faster than those that are not. The measures to liberalize India's industrial policy frame work begun in the late 1970s which consisted of deregulation and delicensing in certain industries, assigning a greater role to the private sector and a gradual shift from direct physical controls to indirect controls (Raj, 1986 and Chandrasekhar, 1988). For India's industrial economy, the 1990s has been a period of transition and structural change. This process of liberalization was further accelerated in 1991. Since the launching of the economic reforms in 1991 and the gradual opening up to external competition, the economic environment transformed dramatically. Following the virtual dismantling of licensing and easing of production, pricing and distribution controls, there has been a transition from a controlled to a market- oriented economy. With the greater participation of Indian economy with the rest of the world, India has experienced large inflows of investment from abroad, a vital source of economic growth. The impact of increased capital inflows in to the Indian economy can well be measured in terms of the growth of GDP, employment, output, wage rate, investment, export, production and productivity of various sectors of the economy, in particular, the industrial sector.

Globally trade is emerging as a powerful engine of economic growth and development. Manufactured products are generally traded goods. Their demand also shows price and income elasticity as a result of which the export industry, unlike agriculture, do not face major market constraint. Raising India's share in the world exports of manufactured products is, therefore, the second important objective for the industrial sector in the Tenth Plan. Bringing about a balanced industrial development in the country is therefore, proposed to be major objective for the sector.

Industrial development is the key factor for the rapid economic development of any country. It is more true in the case of developing countries, since, it would be helpful to combating many economic ills, which they have been facing. Economic reforms introduced in India, particularly since 1991, are aimed at making its economy and industry more competitive. Liberalization and globalization have provided opportunity for the growth and expansion of the industry, and the manufacturing sector in particular.

Participation in the world trade is essential for India as it can yield multiple advantages. Rising exports can augment the availability of much-needed imports while also .It is widely accepted that the high-technology sector is one of the most dynamic parts of any economy. High-tech industries are thought of as an important source of employment growth, profits, and innovation in products and production processes. Accordingly, the high-tech sector has been a center of interest, generating numerous analyses and studies. In a 1997 Monthly Labor Review study, William Luker, Jr., and Donald Lyons stated that "the continuing attention paid to high-tech industries in recent years seems to be rooted in the widespread belief that the innovations they produce can profoundly alter an economy's mix of firms, industries, and jobs.

The Organization for Economic Cooperation and Development (OECD) identifies high-tech industries largely on the basis of their level of research and development intensity (research and development expenditure in relation to value added). In his 1999 study of high-tech employment, Daniel Hecker notes that high-tech firms "devote a 'high' proportion of expenditures to research and development and employ a 'high' proportion of scientific, technical, and engineering personnel." The various approaches to classifying high-tech industries fall into two broad classes: A majority of studies classify industries by the extent to which they employ certain types of workers or undertake certain types of expenditures (input-based criteria), while another group of studies focuses on the nature of the industries' products (output based criteria). Both approaches have certain advantage as well as drawbacks. Input-based approaches have the advantage of resting on easily obtainable, non subjective data—for example, the proportion of an industry's workers in technology-oriented professions or the proportion of industry costs devoted to research and development.

In the absence of wide agreement on the threshold proportions above which an industry should be considered high tech, however, any such choice must be considered arbitrary. Input-based approaches also suffer from a failure to take account of the products of the industry. Thus, high-tech industries identified solely on the basis of inputs may chiefly manufacture products not commonly thought of as high tech. Output-based approaches generally rely on some determination of the level of technical sophistication embodied in an industry's products or the extent to which these products have undergone rapid change. Although following this approach makes it more likely that the products of the designated industries will match popular conceptions of high tech, the judgments about product sophistication or rapid change on which these studies rely tend to be subjective.

Labor productivity relates output to the labor resources used in its production. It is an indicator of the efficiency with which labour is being utilized. High-tech manufacturing strong performance seems consistent with expectations, but the situation deserves a closer look. Economic growth can occur from increases in inputs or from advances in productivity. Increases in inputs impose costs on society, such depletion of resources. Multifactor productivity growth measures changes in output that are not attributed to the changes in combined inputs. While measures of labor productivity provide valuable insights into efficiency, measures of multifactor productivity are more useful in this regard. By accounting for sources of growth from additional inputs—specifically, capital and intermediate purchases— multifactor productivity analysis more closely measures changes in efficiency. The high-tech manufacturing industries do indeed share several key characteristics and tendencies. The most striking commonality is the tendency of high-tech industries to have more rapid rates of growth in the ratios of intermediate purchases to labor and capital to labor than do the non-high-tech industries. Conversely, hours in the high-tech industries tended to decline more rapidly than (or not to grow as quickly as) hours in the non-high-tech industries. Another feature of high-tech industries is their tendency to outperform non-high-tech manufacturing industries in output per hour and unit labor costs. Output per hour is more likely to grow more rapidly, and unit labor costs are more likely to grow more slowly (or decline more rapidly) in high-tech industries than in other manufacturing industries.

Productivity of an organization is defined as the ratio of outputs produced by the organization and the resources consumed in the process. Productivity is used to assess the extent to which certain outputs can be extracted from a given input. There can be many different types of productivity measurement depending on the type of resources considered. Some of the most common types of productivity measurements include labour productivity, machine or capital productivity. The partial productivity ratios are the simplest measure of productivity and are derived by dividing the output by relevant factor input. Naturally, there can be as many partial productivity ratios as there are inputs. The most commonly used and widely reported partial productivity ratios are labour productivity ratio and capital productivity ratio. The partial productivity ratio relates output to the input of a single factor. The increase in partial productivity ratio means that over a period of time more output is possible with decreasing amounts of inputs or with same inputs or same output with lesser inputs. The inverse of these partial productivity ratios implies unit requirement of factor concerned for per unit output. The study of a partial productivity ratio is very helpful in measuring the saving in use of that particular factor over a period of time. Productivity may be measured for all the factors of production taken together. This measure of productivity, called *total factor productivity*, is generally used for measuring.

The performance of the supply side of an economy is often identified with the growth rate of potential output. Potential output is not observed in reality, however, and has to be approximated. The use of the production function method for the measurement of potential output growth takes into account different sources of an economy's productive capacity, namely the contributions of labour, capital and total factor productivity, the latter containing information about technological and locative efficiency and hence about the supply-side functioning. Using the production function, one can discuss changes in the supply-side performance on the basis of the observed simultaneous developments in the quantity of labor, capital and total factor productivity. For instance, an increase in the rate of capital growth accompanied by a rise in trend total factor productivity may signal some improvement in the supply-side performance. Observing an increase in the rate of the capital growth while trend total factor productivity stagnates, one can, in contrast, deduce that the supply side is functioning ineffectively. The production function thus represents a useful and powerful tool for the macro economic analysis and evaluation of the governmental structural policies. Based on the above points, the present study proposes to:

1. Anlayse different types of elasticities-output, employment and wage elasticity

2. Estimate marginal, partial and total factor productivity indices along with their annual trend rates

3. Examine the returns to scale and factor intensity

It is hoped that this study would be of great use to the policy makers in this field of investigation to frame policies keeping in mind the long term objectives for the further growth of these industries.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

The literature relating to the study is discussed under the following headings;

A. Productivity in manufacturing sector

B. Innovation and productivity in manufacturing sector

C. Production function estimates in manufacturing sector

D. Efficiency in manufacturing sector

E. Verification of Verdoorn's law in manufacturing sector

F. Other related studies.

A. Productivity in manufacturing sector

Bjurek and Durevall (2000) analyzed the increase in total factor productivity for Zimbabwe's manufacturing sub sectors against the structural adjustment program implemented from 1991 to1995. Malmquist productivity Index was used to evaluate productivity for thirty one manufacturing sub sectors for the period 1980 to 1995. Further econometric methods were used to test the effect of trade reforms and market liberalization to the structural adjustment program. In general the results suggested a great variation in growth rates across sectors and over time period. There was no growth in the total factor productivity during structural adjustment program except for the last two years where most of the sub sectors showed a growth in total factor productivity. The results of econometric analysis showed only import growth as influencing variable and all other variables measuring trade liberalization to the structural adjustment program. The results of econometric analysis showed only import growth as influencing variable and other variables measuring trade liberalization had no influence on productivity growth.

Susan's Linz (2000) estimated industry wise and regional differences in labour productivity in Russian industry at the beginning of the transition from a planned to a market economy for the year 1992. It was found that firms with below industry – average, labour productivity was expected to experience a higher than average reduction in work force size. Spinning, machine –building, forestry, wood, and paper and construction materials industries ranked lowest in terms of labour productivity. Labour productivity in the Ural, Western Siberia and Black Earth Regions was significantly below that of firms in the Volga region.

Fare, Grosskopf and Margaritis (2001) analyzed the relative trend in the total factor productivity in Australia and New Zealand for the manufacturing sector during 1986-1996. Their objective was to see whether reforms in the two countries have impact on the productivity performance because both countries had a major structural change with different pace and intensity. Malmquist Productivity Index was used to calculate the total factor productivity. Futher it was decomposed into technical efficiency and technical change which helped in analysis to check the source of TFP in the relative performance for two countries. In general, the results suggested that New Zealand performed better than Australian terns of total factor productivity for manufacturing sector. This lower TFP in Australia was due to low capital intensity in production process. Further the major source of TFP growth in New Zealand was technical change rather efficiency change. Productivity nexus in the mill sector for the period from 1966-67 to 1990-91. It was found that capital intensity changes had a greater impact on changes in labour productivity ratio where as the rise in per capita emoluments, reflecting increased well being of the employees, although had a positive influence on changes in labour productivity could not make a significant impact with regard to the movement of capital productivity. There was a more or less increasing trend till 1979-80, but gradually declined till 1988-89 with a slight recovery in the remaining two years of the last two decade. Labour productivity in cotton mill industry had out stripped the rise in capital productivity and contributed to the growth of output and total factor efficiency achieved. Factor productivity increases were largely due to increment in labour productivity.

Biswanth Goldar (2001) analyzed econometrically the relationship between technology acquisition and productivity growth in 82 large chemical firms in India for the years 1985-1986 to 1989-90.The results of the study showed that R&D efforts of the firm had a significant favorable effect on productivity growth. On the other hand the results indicated that technology imports did not make a significant growth. Export intensity, firm size and intermediate goods, import intensity were positively related with productivity growth.

Hay (2002) analyzed the degree of change in productivity through changes in the level of Soumyendra Kishore Datta (2001-02) analyzed partial productivity as well as wage 1991. It was found that labour productivity in the Brazilian manufacturing sector had grown at a rate of 7.35 per cent in the period 1991-95. This period of productivity growth included two different phases. In the first phase, up to 1992 there was a deep recession with output falling, but employment falling ever faster. In the second phase, after 1992 productivity and output grew, but former grew faster to employment at a lesser rate than in 1990-92. There was a marked fall in 1990, followed by rapid growth to 1994. The coefficient suggested a cumulative growth in total productivity of 58 per cent from 1990-94. Production across different sectors. The period chosen for the analysis covered between 1984 and Tarlok Singh (2000) total factor productivity in the manufacturing industries in India. The study used annual data from 1973-74 to 1993-94 for a sample set of ten industries in the manufacturing sector. The results showed that the TFP recorded improvements in all sample industries except for the basic metal industries in which the TFP witnessed a declining trend during the period. The highest growth in TFP was observed in the case of products followed by transport equipment, metallic products, electrical machinery, non-electrical machinery, wool and silk textiles, chemical and jute textiles.

Rao et al. (2003) study aimed at assessing the productivity of the industrial sector in Maharashtra. In 11 industries, the share of capital in the total output has showed a tendency to increase after the firms. The study used the total factor productivity method for measuring efficiency; direct method, the Dormer Index, the Kendrick Index, the Solow Index and Translog method. The study found that the transport equipment industry had experienced a negative total factor productivity growth during the period 1980-89.

Deb Kusum Das (2004) examined the productivity performance of Indian manufacturing under varying trade regimes for the overall period of 1980-2000. It was found that total factor productivity growth of 0.08 percent per annum averaged over 75 three digit industries for the entire period. The total factor productivity growth rates for individual industries were either negative or in the 0 to 2 percent range. The capital goods sector was the only one to register a positive growth. TFP growth in the 1990's was found to be lower than in the 1980. In addition, for all three use-based sectors (intermediate, consumer and capital goods) TFP growth in the second half of the 1990's (1996-2000) was lower than in the first half (1991-95).

Jayamalathi and Manonmani (2004) undertook a study on productivity in selected Manufacturing Industries in TamilNadu for the reference period between 1979-80 to 1997-98. The major objectives of the study were to the study the trends, growth rates and magnitude of variability in factor productivity, estimate production function, analyze the returns to factor input including time variable and, estimate certain important ratios. It was found that labour productivity in all the industries (viz., Basic chemical and chemical products, Rubber, Plastic, Petroleum and Coal products and Non-metallic mineral products) had increased. Capital intensity which has increased significantly in all industries seems to be major factor behind the increase in labour productivity. The share of capital in total factor input had been increasing and that of labour was decreasing in all industries.

One of the studies by **Fu (2005)** for panel of Chinese manufacturing industry was carried out to estimate total factor productivity. TFP growth was estimated for period 1990-1997 using Malmquist Productivity Index. This Index was decomposed into technical progress and efficiency change. The analysis of the results showed that there was no evidence of significant productivity gains at industry level as a result of exports in a transition economy. It was suggested that a developed domestic market and a neutral outward oriented policy is necessary for exports to generate positive effect on TFP growth.

Angelidis and Lyroudi (2006) examined the productivity for Italian banks for period2001-2002. They used the nominal values and natural logarithm of these values as input and output. Productivity change was calculated using Malmquist Productivity Index. The relationship between size of bank and its performance was measured using correlation and ranking correlation. The results suggested that bank size and performance has inverse relationship but it was not significant.

Afzal (2006) estimated total factor productivity for the large scale manufacturing sector from1975 to 2001 using three different approaches. In the first approach classical models were used and comparison of four models was made. Simultaneous equation approach was used at second step to measure the contribution of factors affecting productivity of large scale manufacturing. At third step autoregressive models were used to forecast productivity. Overall results showed that productivity was affected by many factors like labor, capital, gross national product and percapita income. Further, different economic models were applicable and predictable to the data of large scale manufacturing sector of Pakistan and macroeconomic policies might help in improving.

Kong and Tongzon (2006) examined the total factor productivity for ten major sectors of Singapore during 1985-2000. They used the non-parametric, frontier methodology known as data envelopment analysis to calculate the Malmquist Productivity Index at sectoral level. The analysis of the results identified the best practiced sectors and straggler in terms of efficiency change, technical change and total factor productivity change. These three productivity estimates were also adjusted for the effect of inflation and business cycles so these became more reliable for policy making.

Madheswaran et al. (2007) by applying a stochastic Production Frontier to sector-level data within manufacturing sector in India; they examined Total Factor Productivity (TFP) growth during 1979-80 to 1997-98. The analysis had focused on the trend of technical progress (TP) and Technical Efficiency change (TEC). Their results suggested that the TFP growth in a large number of industries have improved during 1997-98 compared to 1980-81. TFP growth was mainly driven by TP not by TEC in case of Indian Industry.

Basti and Akin (2008) compared the productivity of domestic owned and foreign owned firms operating in Turkey. They selected non financial firms listed on Istanbul Stock Exchange for period 2003-2007. Nonparametric technique called DEA was used to calculate Malmquist Index as measurement of productivity. This Malmquist productivity was further decomposed into efficiency change and technical change. The results of the study indicated that there were no differences in terms of productivity of domestic owned and foreign owned firm. The average productivity of both times of firms decreased throughout the period under analysis except 2006.

Gayathri and Manonmani (2008) undertook a study on productivity, employment and wages in the aggregate manufacturing sector of India for the reference period between 1990-91 and 2004-05. The major objectives of the study were to analyse the partial and total factor productivity trends, find out the sources of productivity change, examine the relationship existing between wage and productivity and analyze the trends in distribution of productivity gains. The study found that capital productivity had either declined or stagnated to mean that capital requirement per unit of output had increased. The total factor productivity had increased significantly. Increase in total factor productivity implied that overall efficiency of the sector was increasing. Capital intensity had increased significantly in the sector, which implied that more and more capital is required for increasing employment. Growth in value added had significantly and positively related to productivity. The share of labour in total factor input had been declining. The relative factor price of labour had increased in the periods where its share in total input had decreased. The movement of wages was positively related with labour productivity.

Gomati and Manonmani (2008) undertook a study on the productivity performance of manufacturing sector of TamilNadu in the Pre and Post Liberalization period for the reference period between 1979-1991 (pre-liberalization period) and 1991-2003 (post-liberalization period). The major objectives of the study were to analyze the partial and factor productivity trends in the pre and post-liberalization period, find out the sources of productivity change in the pre post-liberalization period and examine the relationship existing between wage and productivity in the pre and post-liberalization period and analyze the trends in factors share in the pre and post liberalization period. It was found that labour productivity had increased in the manufacturing sector of TamilNadu. This implied that labour productivity in an industry can be increased by a host of factors such as capital intensity, economies of scale, growth of industry, and work environment. Capital intensity seems to be major factor behind the increase in labour productivity. The total factor productivity had increased in both the periods, implying overall efficiency of the sector.

Lili Wang et al. (2008) forced on the contribution of structural change to Aggregate Manufacturing and Industrial productivity in China during the period 1980- 2000. Using shift-share techniques, this study examined three types of structural change:

changes in the sectoral structure of production, changes in the ownership structure, and changes in the regional structure of production. Overall productivity growth was slow in the 1980s, but accelerated dramatically from 1990 onwards. In 1980s the study found evidence of a structural change bonus, with sectoral shifts contributing 24 percent to overall productivity growth. When productivity growth accelerated in the 1990s, the contribution of the shift effect dropped to a mere 3.3 percent. In contrast to sectoral changes, changes in the ownership structure in the early 1980s are contributed negatively to overall productivity growth. The contributions of ownership change positive after 1985, reaching 23 percent of productivity growth in the period 1992-1997. Shifts in ownership explained a substantial part of productivity growth during the productivity boom. Likewise shifts in ownership, regional shifts initially contributed negatively to productivity growth till 1992, and positively thereafter. However, the general contributions of regional shifts in lower than the contributions of sectoral and ownership shifts. Contrary to initial expectations, the regional analysis of productivity trends does not indicate regional divergence.

Manjappa and Mahesha (2008) analyzed productivity performance of selected capital –intensive and labour – intensive industries in India during reform period. The total factor productivity growth was estimated by applying ratio form of Cobb-Douglas (C-D) production function on the panel data of 10 manufacturing industries by classifying them in to capital-intensive and labour –intensive industries for the period 1994 to 2004.The investigation revealed that four out of five industries in capital – intensive segment showed productivity growth during the sample period, while one has recorded no change. A somewhat contrasting picture was observed for labour- intensive sector, where productivity decline was statistically significant in three industries.

Rajan et al. (2008) analyzed total factor productivity in selected Indian manufacturing industries, at the 3-digit level NIC classification, over the period 1973-74 to 2004-05. The study examined the productivity growth for two sub-periods, i.e.,1973-74 to 1992-93 (pre-reform period) and 1993-94 to 2004-05 (post-reform period), for possible structural changes due to policy reforms. As far as iron and steel industry was concerned, productivity growth had declined in the second sub-period (post-reform period). Technological progress during the 1990’s was significantly slackened though it remained positive. On the other hand, aluminum and refined petroleum industries have maintained consistency in their productivity growth without much volatility. It was worth noting that the productivity in refined petroleum products has continued to raise consistently inspire of two big oil crises and increasing cost of crude oil. Labour productivity for all the three industries showed a positive and significant trend.

Maniklal Adhikary and Ritwik Mazumder (2009) examined the Liberalization and Spatial Variation in Manufacturing Sector Productivity: A study of Selected Indian States. The study was intended to search for regional inequalities in manufacturing sector productivity during the three distinct phases of liberalization since 1981 across four traditionally industrially developed states- West Bengal, Tamil Nadu, Maharashtra and Uttar Pradesh representing respectively. The study found that the strong liberalization programmed of 1991 has resulted in growth of labour in excess of capital lending to a sharp fall in capital-intensity growth in West Bengal and Uttar Pradesh. The growth of TFPG was poor in all the four states. West Bengal was the only state where TFPG exhibits a continuously rising trend. Interestingly, TFPG growth was significantly higher during the post 1991 period in all states with the expectation of Uttar Pradesh.

B. Innovation and productivity in manufacturing sector

Unel Bulent (2003) investigated productivity trends in India's (registered) manufacturing sectors during the 1980s and 1990s. The main findings of the paper were (i) labor and total factor productivity (TFP) growth in total manufacturing and many of the component sectors since 1980 were markedly higher than that in the preceding two decades, although the extent of the acceleration in TFP growth depends critically on the underlying assumptions about factor elasticities and the assumed structure of the production function; (ii) productivity growth for total manufacturing as well as for many subsectors picked up further after the 1991 reforms; and (iii) classification of the best performing sectors and the weakest performing sectors, based on comparative TFP, remained robust to changes in underlying assumptions.

Spyros Arvanitis (2006) investigated the determinants of innovation performance and the impact of innovation performance on labour productivity of Swiss manufacturing firms in the period 1994-2002. The data used in this study came from the KOF panel data base and were collected in 1996, 1999 and 2002 respectively based on a questionnaire quite similar to that used in the Community Innovation Surveys (CIS). The use of a wide spectrum of indicators helped to test the robustness of the specification of the innovation equation as well as the robustness of the impact of innovation on economic performance. A clear-cut positive effect of innovation on labour productivity was found.

Arpad J. Abraham and T. Kirk White (2006) using a unique database that covers the entire U.S. manufacturing sector from 1976 until 1999, estimated plant-level total factor productivity for a large number of plants. Time series properties of plant-level idiosyncratic shocks to productivity, was characterized taking into account aggregate manufacturing-sector shocks and industry-level shocks. Plant-level heterogeneity and shocks are a key determinant of the cross-sectional variations in output. We compare the persistence and volatility of the idiosyncratic plant-level shocks to those of aggregate productivity shocks estimated from aggregate data was compared. It was found that persistence of plant level shocks was surprisingly low. Finally, it was found that estimates of the persistence of productivity shocks from aggregate data have a large upward bias. Estimates of the persistence of productivity shocks in the same data aggregated to the industry level produce autocorrelation estimates ranging from 0.80 to 0.91 on an annual basis. The results were robust to the inclusion of various measures of lumpiness in investment and job flows, different weighting methods, and different measures of the plants' capital stocks.

Avaneendra Misra (2007) focused on the impact of India's economic reforms on industrial structure and productivity. Production Function and Productivity in aggregate manufacturing over the 1980-81 to 1995-96 periods was analysed in this paper. The discussion was based on the ASI data and covered both two and three- digit level of industries. The performance of manufacturing sector in India was quite low during the period. This however, was not only the result of exogenous factors, but also the consequence of the type of policies being followed under economic reforms. The study concluded that if mistakes were made in the past, they need to be corrected. But efforts should be made to ensure that demand is high enough for more output to be produced more people to be employed, poverty to be reduced.

Ganna Vakhitova and Tetyana Pavlenko (2010) paid major attention to the impact of the government support on firm's research and development expenditures, innovations and productivity. The results showed that government financial support had positive effect on the probability and amount of firm's innovation expenditures but not on the probability of innovation itself, neither for process nor for product innovation. The latter finding emphasized that only the effective government innovation policy positively contributed to the productivity after all. It was found that firms which have introduced new or significantly improved product in the past were more likely to invest into R&D and to come up with a product innovator in the future. The results also suggested that amount of innovation expenditures in the following period was influenced by firm's productivity in the previous period. Finally, similar to Estonia during late transition only process innovation has been found to contribute to productivity of Ukrainian firms.

Crespi, et.al (2010) examined the determinants of technological innovation and its impact on firm labor productivity across six Latin American countries (Argentina, Chile, Colombia, Costa Rica, Panama, and Uruguay) using micro data from innovation surveys. In line with the literature, in all countries firms that invest in knowledge were more able to introduce new technological advances and those that innovate had greater labor productivity than those that do not. Yet firm-level determinants of innovation investment were much more heterogeneous than in OECD countries. Cooperation, foreign ownership, and exporting increase the propensity to invest in innovation activities and encourage innovation investment in only half of the countries studied. Scientific and market sources of information had little or no impact on firm innovation efforts, which illustrated the weak linkages that characterize national innovation systems in those countries. The results in terms of productivity, however, highlighted the importance of innovation in enabling firms to improve economic performance and catch up

Ganna Vakhitova (2010) studied the impact of the government support on firm's R and D expenditures, innovations and productivity for the period 2004-2006. .The results showed that government financial support had positive effect on the probability and amount of firm's innovation expenditures but not on the probability of innovation itself, neither for process nor for product innovation. The latter finding emphasized that only the effective government innovation policy may positively contribute to the productivity after all. It was found that both parts of the "success breeds success" hypothesis work. Firms which have introduced new or significantly improved product in the past were more likely to invest into R and D and to come up with a product innovator in the future. The results also suggested that amount of innovation expenditures in the following period was influenced by firm's productivity in the previous period. Empirical evidence of this was quite rare in the literature. Finally, similar to Estonia during late transition only process innovation has been found to contribute to productivity of Ukrainian firms.

Arza, et.al (2010) adopted the approach to estimate the relationship between innovation and productivity and the realities of innovative activities in developing countries. Panel data for Argentina during the period 1998-2004 was used to estimate a structural model in which different types of firms` innovative behavior—including in-house activities and the incorporation of external technologies fed into the probability of achieving successful results in product and process innovation, which in turn explained labor productivity. The endogeneity of this three-stage process was controlled for. The results suggested that all types of innovative activities were relevant to explain success in product and process innovation, and both were important factors to explained labor productivity. Moreover, investing systematically in R and D implies an extra payoff in labor productivity. These results suggested that investing in different types of innovative activities—and not only in R and D—and doing in-house activities systematically contributed to firms` innovative and economic performance.

Arbelaez, et.al (2011) in their paper attempted to establish a formal relationship between innovation and productivity using Colombian firm-level data. It was found that the production of goods and services new to the firm and to the domestic market enhances firms` sales per worker, and innovation that results in introducing new goods and services to the international market boosts both sales and Total Factor Productivity (TFP). Innovation in processes likewise improves firms` productivity and sales. Finally, innovation in marketing and management increases sales per worker and enhances TFP when investment was made in Research and Development.

Nataraj and Shanthi (2011) using a unique dataset of firm-level surveys that are representative of the entire Indian manufacturing industry, showed that India's unilateral reduction in final goods tariffs increased the average productivity of small, informal firms, which account for 80% of Indian manufacturing employment but have been excluded from previous studies. In contrast, the increase in productivity among larger, formal firms was driven primarily by the concurrent reduction in input tariffs. By examining the effect of the tariff liberalization on the distributions of productivity and firm size, evidences were found consistent with the exit of the smallest, least productive firms from the informal sector. In addition, although the decline in final goods tariffs did not significantly impact average formal sector productivity, it did increase productivity among the top quantiles of the distribution.

O'Donnell and Christopher John O'Donnell (2011) The Bureau of Labor Statistics measured productivity change using an index formula that fails a transitivity test. This means the Bureau is likely to report productivity changes even when outputs and inputs in different (non-adjacent) periods were identical the alternative formulas were i) satisfy all economically-relevant tests from index theory, and ii) can be decomposed into measures of technical change and efficiency change. It was found that the main sources of productivity change were scale and mix efficiency change. This supports the view that firms were technically efficient and rationally change their production plans in response to changes in (expected) prices.

Jacques Yanyun and zhao zhen (2012) investigated relationships between innovation input, output and labor productivity in China for four major manufacturing sectors; textiles, wearing apparel, transport equipment and electronic equipment. It used a large sample of firm level micro data and a structural model in the estimation. The data from 2005 to 2006 was estimated, and results of all the sectors showed positive effects from innovation input to output, and then to firm performance. Globalization has various impacts on innovation, through exports. It had a positive effect on both the decision to carry out R&D, and intensity of R&D input in sectors with competitive advantage, such as textiles and transport equipment, but not in sectors with high levels of overseas capital control, such as electronic equipment and wearing apparel. Owner ship revealed the same story in different sectors, namely that, foreign firms tend to does less in innovation input and output, but they do have higher level of productivity. Moreover, market share, subsidy, firm size and other characters of firms were involved in the estimation, which explained significant difference in engaging in innovation and production. Thus, in all the sectors, market share improves R and D input, continuous R and D input and exports improved new products output. Subsidy sustained R and D input, but not innovation output.

Eva Yamila Catela, et.al (2012) discussed the evolution of firm's productivity and structural heterogeneity (SH) in the Brazilian manufacturing industry in the 2000s. SH was defined (following the Latin American structuralism tradition) as a situation in which a large share of total firms is in the lowest productivity groups of the production structure, and there are very large differences in labour productivity between groups and firms. The paper combined and made compatible several databases on manufacturing production, innovation and micro-social data for Brazil, in order to measure productivity and SH, to analyze its evolution between 2000 and 2008, and to discuss its determinants. Econometric analyses (k-means cluster methodology to identify productivity groups, and ordered probity models to analyse the determinants of SH) showed that increasing returns in innovation and learning prevailed in the 2000s, while policies failed to encourage the catching up process by laggard firms. As a result, SH did not fall in the Brazilian manufacturing sector.

Saba Vahid (2012) focused on the productivity changes of the manufacturing industries in the U.S. from 1997 to 2002. The results showed 5 percent increase in productivity of the whole sector on average over the study period, while the productivity of the wood product manufacturing decreased by 1 percent over the same period. The efficiency decline of the industry was the main contributor to the decline of its productivity. The recent decline in investments on capital and training and education of work force in wood manufacturing industry could be among the factors affected its productivity and if this trend continues, it would affect the productivity and consequently the competitive position of the industry more negatively.

Fulwinder pal singh (2012) analyzed the TFP growth trends in Indian manufacturing sector at both aggregated and disaggregated interstate levels. Using the Malmquist productivity index for panel data set of 16 major industrial state over a period of 29 years spanning over 1979-80 to 2007-08, the study observed manufacturing sector of India was growing with 9.1 percent per annum growth of Total Factor Productivity (TFP) during the entire study period. Out of Sixteen industrial states there were five states namely Uttar Pradesh, Madhya Pradesh, Gujarat, Orissa and Rajasthan where double digit TFP growth has been noticed. The manufacturing sector of Uttar Pradesh was growing with highest TFP growth at the rate of 12.8 percent per annum followed by Madhya Pradesh with TFP growth of 11.8 percent per annum. The analysis of the sources of the TFP growth in Indian manufacturing sector revealed that both technical progress and technical change were equally contributing TFP growth in sector under evaluation. It has also been observed that at all India level efficiency change was greater than technical progress.

Jajri, et.al. (2013) attempted to analyse trend of, technical efficiency, technological change and TFP growth in the Malaysian manufacturing sector. The analysis was based on data from the Industrial Manufacturing Survey of 1985 to 2000 collected by the Department of Statistics, Malaysia using Data Envelopment Analysis (DEA). The results showed that during the period under study, TFP growth was increasing and it was the major contributor of TFP growth in technical efficiency. Nevertheless, technological change show increasing trend over time. The industries that experienced high technical efficiency are food, wood, chemical and iron products. However, for food and wood industries technical progress was higher than technical progress. The other industry that showed larger technical progress than technical efficiency was textile industry but both values were below unity.

C. Production function estimates in manufacturing sector

Dana hajkova and Jaromir Hurnik (2007) tested the application of the Cobb-Douglas production function for the Czech economy. They applied a more general form of production function and allowed labor share to develop according to the empirical data. For the period 1995–2005, they did not find significant difference between the calculation of the supply side of the Czech economy by the Cobb--Douglas production function and a more general production function.

The efficiency of the large scale manufacturing sector of Pakistan was examined by **Mahmood et. al. (2007)** using the stochastic production frontier approach. This frontier was estimated for two periods 1995-96 and 2000-01, for 101 industries at the 5-digit PSIC. The results of this study showed that there was some improvement in the efficiency of the large scale manufacturing sector, although the magnitude was small. The results were mixed at the disaggregated level, whereas a majority of industries had gained in terms of technical efficiency and some industries were also weaker in terms of their efficiency level.

Manjappa and Mahesha (2008) analyzed productivity performance of selected capital – intensive and labour – intensive industries in India during reform period. The total factor productivity growth was estimated by applying ratio form of Cobb-Douglas (C-D) production function on the panel data of 10 manufacturing industries by classifying them in to capital-intensive and labour –intensive industries for the period 1994 to 2004.The investigation revealed that four out of five industries in capital – intensive segment showed productivity growth during the sample period, while one has recorded no change. A somewhat contrasting picture was observed for labour- intensive sector, where productivity decline was statistically significant in three industries.

Upender, **and Mulakala Upender (2009)** analysed the magnitude of the elasticity of substitution between labour and capital across twenty six major Industries [Factory Sector] in India has been estimated in the present paper by fitting a Constant Elasticity of Substitution Production Function for the year 2004-05.The empirical results emerged out of the cross section data demonstrate that the estimate of the elasticity of substitution between labour and capital across the major Indian Industries was significantly more than unity implying that substitution possibilities were rather more in favour of labour in the Indian major Industries.

Santosh Kumar Sahu Krishnan Narayanan (2011) estimated the transcendental logarithmic production function and analyse the relationship between energy intensity and total factor productivity (TFP). The estimation of TFP was based on four inputs model; labour, capital, material and energy. The findings suggested that labour and material inputs played major role as compared to the capital and energy input. Further, estimates suggested that age of the firm, export intensity and disembodied technology import were positively related to the TFP, where as ownership, energy intensity, embodied technology import and R&D intensity were negatively related to TFP of the Indian manufacturing industries. In addition, energy efficient firms also found to have high levels of TFP. This implied the need for fostering energy efficiency at firm level in Indian Manufacturing.

Moyazzem Hossain, et.al (2012) considered Cobb-Douglas (C-D) production function with additive error and multiplicative error term. The main purpose of this paper was to select the appropriate Cobb-Douglas production model for measuring the production process of some selected manufacturing industries in Bangladesh. They used different model selection criteria to compare the Cobb-Douglas production function with additive error term to Cobb-Douglas production function with multiplicative error term. Finally, by estimating the parameters of the production function by using optimization subroutine. It was observed that, the Cobb-Douglas production function with additive error performed better for the selected manufacturing industries based on the data under study period. There were economies of scale in the manufacturing of Drugs & pharmaceuticals, Furniture & fixtures (wooden), Iron & steel basic, Leather footwear, fabricated metal products, Plastic products, printing & publications and Tobacco. There were diseconomies of scale in the Beverage, Chemical, Glass & glass products, Leather & leather products, Paper & paper products, Textile, Wood & crock products industries, Transport equipment industries.

D. Efficiency in manufacturing sector

Singh (2000) studied the productivity efficiency of 21 State Road Transport Undertakings (STUs) in India over 1984-85 to 1996-97. It was observed that there were wide disparities among state road transport undertakings according to their productive efficiency levels and growth. On average small-sized state road transport undertakings experienced higher level of productive efficiency than their large counterparts. And by and large Tamil Nadu state road transport undertakings seem to be more productive than their counter parts operating in other states of the country. The average annual growth of productive efficiency ranged from 2.39 per cent to 4.41 per cent. The distribution of ranks of state road transport undertakings with respect to their productive efficiency level had remained broadly unchanged over the year.

Susan J Linz (2000) estimated industry wise and regional differences in labour productivity in Russian industry at the beginning of the transition from a planned to a market economy for the period 1992. It was found that firms with below -industry – average, labour productivity was expected to experience a higher than average reduction in work force size.

Spinning, machine –building, forestry, wood, and paper and construction materials industries ranked lowest in terms of labour productivity. Labour productivity in the Ural, Western Siberia and Black Earth Regions was significantly below that of firms in the Volga region.

Chidambaram and Muthukrishnan (2003) made an attempt to measure the operating efficiency in terms of productivity of Madras Cements and India Cements, the two major cement companies in Tamil Nadu for the study period 1990-91 to 2001-02. The study used three ratios namely overall productivity, selling, distribution and administration, productivity and labour productivity. The overall productivity indicated that Madras Cements performance was outstanding than India Cements. In the area of selling, distribution and administration and productivity, the Madras Cements performance was commendable. Martly's F-max applied to determine whether the three areas of productivity had any difference or not showed that difference were found in variance of Madras Cements.

Goldar et al. (2003) analyzed the effect of ownership on efficiency of engineering firms in India in the 1990s, a decade of major economic reforms with help of a stochastic frontier production function. They compared technical efficiency among three groups of firms in Indian engineering: (i) firms with foreign ownership, (ii) domestically owned private sector firms and (iii) public sector firms. The results indicated that foreign firms in Indian engineering industry have higher technical efficiency than domestically owned firms. No significant difference in technical efficiency was found between private sector and public sector firms among the domestically owned firms. There were indicators of a process of efficiency convergence - the domestically owned firms tending to catch up with foreign owned firms in terms of technical efficiency. The results showed a positive relationship between international trade orientation of a firm and its level of technical efficiency. The study observed the efficiency raising effects of import liberalization.

Mitra et al. (2003) examined the effect of in infrastructure on manufacturing industries, Total Factor Productivity (TFP) and Technical Efficiency (TE) in case of Indian states for 15 industries from 1976-92. Consumption goods industries showed constant returns to scale whereas heavy industries showed decreasing returns to scale. Light industries were less capital intensive than heavy industries. The productivity growth differences showed that Indian heavy industry exhibited a higher growth potential in terms of total factor productivity than did light industry. The impact of infrastructure on long run productivity by manufacturing industry showed the greatest impact on industrial total factor productivity growth. The second item of importance was financial development. The impact of financial development on total factor productivity was more significant since the country was long subject to a controlled financial policy regime that hindered the development of savings. There existed significant difference in technical efficiency among states which was partly attributed to differences in physical, economic and social infrastructure.

Rao et al. (2003) study aimed at assessing the efficiency of the industrial sector in Maharashtra. In 11 industries, the share of capital in the total output has showed a tendency to increase after the firms. The study used the total factor productivity method for measuring efficiency; direct method, Dormer Index, Kendrick Index, Solow Index and Translog method. The study found that the transport equipment industry had experienced a negative total factor productivity growth during the period 1980-89.

Golder et al. (2004) analyzed the effect of ownership on efficiency of engineering firms in the 1990s, a decade of major economic reforms. Technical efficiency of firms were estimated with the help of stochastic frontier production function for three groups of firms namely (i) firms with foreign ownership, (ii) domestically owned private sector firms and (iii) public sector firms. The results clearly indicated that foreign firms in Indian engineering industry had higher technical efficiency than domestically owned firms. There were indications of a process of efficiency convergence (i.e.) the domestically owned firms tending to catch up with foreign owned firms in terms of technical efficiency. In the first half of the 1990s there were significant positive productivity spillover effects from foreign owned firms. This effect became relatively less important in the second half of the 1990s when access to imported inputs became an increasingly more important source of efficiency of engineering firms in India.

Nikaido (2004) examined the technical efficiency of two-digit industry- groups belonging to Small Scale Industries and the relationship between the measured technical efficiency and firm’s size and location by employing the stochastic production frontier. It was found that on average industry groups operate at 80 percent of the potential maximum production frontier, although diversification among industry groups is observed. The agglomeration of firms has a positive effect on the measured technical efficiency. While the firm size has a negative effect on it. However, he used a two step procedure (not the single step MLE) to identify the factors that explain the technical efficiency differentials across firms.

Ray (2004) examined the changes in competitiveness of Indian manufacturing firms through increased efficiency over the period 1991-01. The firm level efficiencies had been calculated using data from 27 industry groups and using the Data Envelopment Approach (DEA). It was found that ownership of domestic firms by MNE's clearly helped in enhancing the efficiency of these firms. Developing countries had progressively adopted market friendly reforms during 1980s and 1990s. Productivity spillovers took place when the entry or presence of MNE's affiliates leads to efficiency benefits for domestic firms. There was clear scope for more reforms that can make the process less dependent on foreign firms.

Anup Kumar Bhandari and Pradip Maiti (2007) studied the Efficiency of Indian Manufacturing Firms: Textile Industry as a case study. The study considered five years with gaps of between two and six years: 1985–1986, 1990–1991, 1996–1997, 1998–1999, and 2001–2002 in which the study has been chosen the textile industry as a case study on the grounds that it is one of the largest industries in India. Translog stochastic frontier production functions were fitted to firm-level cross-sectional data on India's textile firms for each of five selected years to estimate Technical Efficiency (TE) of firms. The result was found that average Technical Efficiency (TE) varied between 68 to84 percent across these years and that individual TEs vary with firm-specific characteristics such as size and age. Further, public sector firms were found to be relatively less efficient.

Idris Jajri and Rahmah Ismail (2007) attempted to analyze the trend of technical efficiency, technological change and Total Factor Productivity (TFP) growth in the Malaysian manufacturing sector. The results showed that during the period of study, TFP growth has increased and the major contribution to TFP growth was from change in technical efficiency. Nevertheless, technological change also showed increasing trend overtime. The industries that experienced high technical efficiency are food, wood, chemical and iron products. However, for food and wood industries technical efficiency was the textile industry; however both the values obtained are below unity.

Sunil Kumar and Nitinarora (2007) in their article analyzed "Technical and scale efficiency in Indian, manufacturing sector", A cross-sectional analysis using deterministic frontier approach". The mean of Overall Technical Efficiency (OTE) scores has turned out to be 0.603 (with standard deviation of 0.177) and OTE score ranged from a minimum of 0.345 to a maximum of 1. The major finding of this study was that in manufacturing sector, on an average, 39.7 percent of resources were being wasted in the production process. Only 9 industrial groups attained the status of globally efficient groups with OTE score equal to 1. The decomposition analysis of OTE score into its two mutually exclusive non additive components viz., Pure Technical Efficiency (PTE) and Scale Efficiency (SE) delineate that 31.2 percentage points of 39.7 percentage of Overall Technical in Efficiency (OTE) was due to inappropriate management practices being adopted by firm's managers in organizing the inputs in the production process. The remaining part of the OTE was due to the firms not operating at optimal scale size. Further, it was observed that 62 percent of groups are operating at above their optimal size and thus, experiencing decreasing returns-to-scale. The result of Tobit regression analysis revealed that the proxy variables for capital deepening, profitability and degree of skill formation have a positive impact on the OTE of Indian manufacturing sector.

Sabuj Kumar Mandal and Madheswaran (2008) made a study on environmental efficiency of the Indian Cement Industry: An Interstate Analysis. The study aimed at measuring environmental efficiency within a joint production framework of both desirable and undesirable output using Data Envelopment Analysis. Carbon dioxide was considered as an input in one context and as an undesirable output in the other with the environmental efficiency being defined accordingly. The study used 3 digit sate level data from the Annual Survey of Industries for the years 2000-01 through 2004-05; the proposed models were applied to estimate environmental efficiency of Indian cement industry. Therefore the empirical showed that Indian cement industry, faced with environmental regulation, has the potential to expand desirable output and contract undesirable output with the given inputs. The empirical results also showed that compared to the initial year, 2000-01, the average environmental efficiency measures, derived from all the four models, declined in 2004-05. Regarding the correlation between availability of coal in a state and its environmental performance, results showed that, larger the availability of coal in a particular state, lower is the environmental efficiency experienced by it and subjected to environmental regulation, has the potential of expanding desirable output and reducing the undesirable one from the given inputs. However regulation has a potential cost in terms of lower feasible expansion of desirable output as compared to unregulated scenario because to control pollution, firms are bound to divert some of their productive resources that could, otherwise, have been used for producing desirable output.

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E. Verification of verdoorn's law in manufacturing sector

Miguel A. Leon-Ledesma (1998) examined on economic growth and Verdoorn's law in the Spanish Regions, 1962-1991. This paper was attempted to test Verdoorn's Law with different specifications for the 17 Spanish regions using a pool of average rates of growth between 1962-73, 1973-83 and 1983-91.The result was found that there is overwhelming support for the hypothesis of increasing returns to scale in the manufacturing sector of the Spanish regions. The result showed that those sectors with low productivity or a weak relationship between inputs and production (such as agriculture, construction and some services) can transfer labour to the increasing returns ones without affecting the overall productivity of the economy. From the test of the static-dynamic paradox, the outcome is that Verdoorn's Law has not been derived from a Cobb-Douglas production function. Moreover, in the case of the Spanish regions, the paradox was also found using Rowthorn's specification, casting doubts on the adequacy of the production function approach to measuring economic growth. That was, the analysis of the level of productivity and output may be incomplete without the consideration of their dynamic behavior.

Gustavo Britto (2008) for the period from 1996 to 2002 in Brazil for 6,027 firms found that the regressions using different specifications, which included a proxy for the rate of growth of capital stock, revealed a Verdoorn coefficient remarkably similar to those estimated using aggregated data. The success of the estimations had important theoretical and practical implications. From a theoretical point of view, the regressions showed that, regardless of the true level at which the increasing returns to scale are generated, it is possible to successfully estimate

Verdoorn’s Law at the lowest level of aggregation. From a more practical point of view, the exercise showed that the manufacturing industry in Brazil is dynamic on the whole, given that firms’ productivity growth showed to be highly sensitive to output growth. The significant Verdoorn coefficients can be taken as an indication of the dynamism of the manufacturing industry in the sense that firms are able to translate the pull of output grow into productivity gains. From the point of view of the long-run path of economic growth in general, and the country’s inability to achieve higher growth rates after the 1980s in particular, the results presented suggest that the relative loss of importance of the manufacturing sector from the 1980s is a key piece of the puzzle.

Ferdinando Ofria and Emanuele Millemaci (2010) investigated the validity of the Kaldor-Verdoorn’s Law in explaining the long run determinants of the labor productivity growth for manufacturing industry sector of the main developed economies (Western European Countries, Australia, Canada, Japan, and United States). The period of the study was from 1973-2006 using the data provided by the European Commission - Economics and Financial Affairs. The study found that under certain conditions implied a high degree of increasing returns to scale for the Italian manufacturing in the period 1973-2006, was near the 0.65 estimated in Bianchi (2002) for the period 1951-1997 and less than the 0.75 obtained in Gambacorta (2004) for the period 1970-2002. This result was also similar to the one found in Afria (2008) for the Northern and Central areas of Italy in the longer period 1951-2006, while the “Mezzogiorno” showed a higher parameter. Also USA showed significant Verdoorn coefficients with values that are around a half of the ones observed for the Italian manufacturing (0.3). Australia and Belgium showed a significant *n* parameter at least in an equation with the substantial high values of 0.55 and 0.83, respectively. The results support the validity of the KVL for Australia, Belgium, Italy and USA. On the contrary, for the other observed countries, the hypothesis of constant returns to scale cannot be rejected.

In order to test the verdoorn’s law statistical relationship between the long-run growth rate of labour productivity and the growth rate of output **Concetta Castiglione (2011)** based on a time series analysis and formulated the law interms of cointegration and Granger-causality between manufacturing output and labour productivity. Quarterly U.S. data for 1987-2007 was used to test the pattern implied by the law. Results showed that manufacturing production and labour productivity were variables that were integrated of order (1, 1), and were also co-integrated. The impulse response function showed that a shock on one variable had a positive impact on the other variables.

Emanuele Millemaci and Ferdinando Ofria (2012) investigated the validity of the Kaldor-Verdoorn's Law in explaining the long run determinants of the labor productivity growth for the manufacturing sector of some developed economies (Western European Countries, Australia, Canada, Japan and United States)considering the period 1973-2006 using data provided by the European Commission - Economics and Financial Affairs. The findings suggested that the law is valid for the manufacturing as countries show increasing returns to scale. Capital growth and labor cost growth did not appear important in explaining productivity growth. The estimated Verdoorn coefficients were found to be substantially stable throughout the period.

González Torres et.al (2013) estimated the Verdoorn's coefficients for the 32 states in Mexico for the period of 1985-2004 through the use of the Ordinary Least Square method (OLS) and the pool data technique for an added analysis at subsector levels of the manufacturing industry. The purpose of this paper is to explain regional divergences in Mexico by identifying those factors that influence economic growth and that would allow the proposal of regional policies that can help reduce the observed differences, and by contributing to the development of the country as a whole. Consistent results were found with Verdoorn's Law by detecting increasing returns in the manufacturing industry, both by regions and by subsectors. The states that show lower Verdoon's coefficients (higher returns to scale) are definitely the ones that have grown the most.

F. Other related studies.

Siddharthan and Lal (2004) analyzed the impact of FDI spillover on the productivity of Indian enterprises for the post liberalization years 1993-2000. The study showed the presence of significant spillovers effects from FDI. During the initial years of liberalization, the spillovers effects were modest but later on increased sharply and stabilized towards the end. However, not all domestic firms gained equally from the spillovers.

Domestic firms that possessed higher labour productivities and lower productivity gaps with MNE were able to enjoy higher spillovers while those with large productivity gaps could not benefit much .Consequently firms with endowments in terms of productivity and technology benefited from liberalization and FDI presence. Firms with large productivity gaps became the victims.

Adolphus J. Toby (2005) studied corporate liquidity management practices of Nigerian- quoted Manufacturing Enterprises in 2005. His study was intended to investigate and subsequently improve the capability of corporate finance executives in handling acute liquidity shortages through optimal cash flow management practices within risk-return frame work in the Nigerian quoted manufacturing industries. He found that the liberalization of the Nigerian banking system limited the effectiveness of the monetary transmission mechanism by encouraging high interest rates and acute liquidity shortages in the manufacturing sector.

Rashmi Banga (2005) examined on "Impact of Liberalization on Wages and Employment in Indian Manufacturing Industries". The study examined the impact of foreign direct investment (FDI), trade and technology on wages and employment in Indian organized manufacturing industries in the post reforms period. The study estimated dynamic panel data (DPD) model using generalized method of moments (GMM). The analysis was undertaken for 78 three-digit level industries. The impact of technology was captured through three components, which are research and development intensity, import intensity of capital goods and import intensity of soft technology. An index for technology acquisition was also constructed using principal component analysis to estimate the impact of technological progress. The results showed that FDI, trade and technological progress have differential impact on wages and employment. While higher extent of FDI in an industry leads to higher wage rate in the industry, it has no impact on its employment. On the other hand, higher export intensity of an industry increased employment in the industry but has no effect on its wage rate. Technological progress was found to be labour saving but does not influence the wage rate. Further, the results showed that domestic innovation in terms of research and development intensity has been labour utilized in nature but import of technology has unfavorably affected employment. An immediate policy direction that emerges from the study is that to improve the employment potential of the economy trade should be encouraged and higher incentives should be generated for attracting FDI into export-oriented sectors. As the economy opens up, cost adjustments become increasingly important and flexibility labour laws are required to facilitate cost adjustments.

Selvaraj (2007) analyzed the manufacturing industry at all India level covering 24 years period from 1981-82 to 2004-05, to identify the effect of liberalization policy. The total period is divided in to sub periods, namely period 1 (1981-82 to 1990-91), period 2 (1991-92 to 2004-05) and over all period (1981-82 to 2004-2005). The growth of total factor productivity was mainly because of growth in labour productivity. The study suggested that to develop the country's manufacturing industry, we should increase the efficiency of input use, particularly capital.

Gustavo Britto (2008) for the period from 1996 to 2002 in Brazil for 6,027 firms found that the regressions using different specifications, which included a proxy for the rate of growth of capital stock, revealed a Vendor's coefficient remarkably similar to those estimated using aggregated data. The success of the estimations had important theoretical and practical implications. From a theoretical point of view, the regressions showed that, regardless of the true level at which the increasing returns to scale are generated, it is possible to successfully estimate Vendoorn's Law at the lowest level of aggregation. From a more practical point of view, the exercise showed that the manufacturing industry in Brazil is dynamic on the whole, given that firms' productivity growth showed to be highly sensitive to output growth. The significant Vendor's coefficients can be taken as a indication of the dynamism of the manufacturing industry in the sense that firms are able to translate the pull of output grow into productivity gains. From the point of view of the long-run path of economic growth in general, and the country's inability to achieve higher growth rates after the 1980s in particular, the results presented suggest that the relative loss of importance of the manufacturing sector from the 1980s is a key piece of the puzzle.

Lakshmanan et.al (2013) found that India's manufacturing exports have risen impressively in the past decade or so and found to be directly linked to the world GDP and inversely related to real effective exchange rate (REER). Indian manufacturing industries have certain inherent strengths and advantages in having a relatively inexpensive, adequate and skilled labour force, cost-effective and competitive prices of goods produced, large manufacturing base and proximity to fast growing Asian markets. India is one of the leading producers and exporters in a number of commodities and enjoys significant advantages in terms of lower labour costs as compared to other economies. Nevertheless, India's competitiveness is lost on account of lower labour productivity and higher input and material costs. To improve the competitiveness of the Indian manufacturing goods, issues like further diversification of export basket, upgradation of export quality, improvement in productivity, increased technology intensity in production, enhanced R&D activity, encouraging business environment, less cumbersome regulatory environment, flexible labour laws, removal of infrastructural bottlenecks and SME related issues need attention of all concerned.

Diaz and Sanchez (2004) analyzed the performance of the small and medium Spanish manufacturing firms during 1995-2001. The focus of the study was on the technical inefficiency and its determinants for these firms using stochastic frontier production function. The findings of the results suggested that small and medium firms are more efficient than large firms and these small firms can easily exit the market under economic difficulties. Further if the market share, foreign shareholders, proportion of temporary over fixed workers, the intensity of capital and firm legal status are controlled, small and medium sized firms tend to be more efficient.

Mukherjee (2006) in his paper analyzed the growth dynamics of the Informal Manufacturing Sector (IMS) in India over the period 1984-2000 and also made an attempt to identify the plausible factor determining the growth pattern. The informal manufacturing sector had seen a flurry of research activities over the last few years. It was found that the growth pattern of informal manufacturing sector had changed significantly from the pre-reform period to post-reform period. It had provided employment to a substantial number of jobseekers especially in the post-reform period. It had expanded substantially to compensate the slackening employment opportunities in the organized sector. The growth oriented activities (i.e.) non metallic mineral products, basic metal, transport equipment, beverage and rural basic chemicals and metal products sector were also exhibiting positive employment growth in most as well as at the national level in the post-reform period indicating that they are the dynamic sector.

Bhanu (2006) made a study on the performance of industries which assessed by analyzing capacity and its utilization through there exists other indicators of performance. Based on Wharton Index; Wharton and RBI methods where used in this study to measures the capacity and capacity utilization in the aggregate of sixteen two- digit and thirty-three selected industries during the period 1980-81 to 2000. Cyclical variations are observed in the rates of utilization, but utilization had been higher during 1980-85 and 1996-2000. An analysis of the rate of capacity in the use-based group of industries revealed varied rate of utilization under different methods and during different sub-periods. Utilization was higher for basic; intermediate and consumer goods and lower for capital goods industries. Utilization was higher under Wharton Index method and lower under Modified Wharton and RBI methods.

Pulak Mishra (2008) studied about the concentration markup relationship in Indian manufacturing sector. The paper attempted to explore the inter relationship controlling for various other aspects of market structure, firm's business strategies, their past performance and policies of the government in a dynamic framework. It is observed that lagged PCM has a statistically significant positive impact on its current level. In other words, industries with greater PCM in the previous year experience greater profit margin in the current year as well. In addition, rate of growth of sales, size of the market and exports intensity also have statistically significant positive impact on profitability, whereas selling efforts have negative impact on the same. However, minimum efficient scale or capital intensity ratio fail to create any effective entry barrier and hence, to influence PMC in a significant way in the long run. Similarly, technology strategies also do not have any significant impact on inter-industry variations in profit margin.

METHODOLOGY

III. METHODOLOGY

The methodology relating to the current study is discussed under the following heads:

1. Selection of the topic
2. Selection of the variables
3. Data Base of the study
4. Tools of analysis

1. Selection of the topic

The economic development of a country depends mainly on industrial development. In manufacturing sector, the scope for internal as well as external economies is greater than in other sectors. It acts as an instrument both for creating capacity to absorb excess labour power and for diversifying the market required to boost economic development. Therefore, the present study is attempted to analyse the productivity, production function and elasticities in the manufacturing sector of India- disaggregating in to various high technology manufacturing sector.

2. Selection of the variables

Net Value Added (NVA) was taken as output, since trends are not affected significantly by the use of net value added. Also ambiguity in the calculation of depreciation can be overcome if net value added is taken as a measure of output. Labour input consisted workers directly involved in production. The fixed capital was taken into account as capital input. Wages included remuneration paid to workers.

3. Data Base of the study

The basic data source of the study was Annual Survey of Industries (ASI) published by Central Statistical Organization (CSO), Government of India covering the period from 2001-02 to 2010-11.All the referred variables were normalized by applying

Gross Domestic Product (GDP) deflator. The GDP at current and constant prices were obtained by referring to Economic Survey, published by Government of India, Ministry of Finance and Economic Division, New Delhi.

4. Tools of analysis

a. Partial factor productivity indices

Partial factor productivity measures the ratio of output to one of the inputs setting aside interdependence of use of other output. Labour productivity (NVA/L) is measured as a ratio of value added to total number of persons employed. Capital Productivity (NVA/K) is measured as a ratio of value added to gross fixed capital.

b. Total factor productivity (TFP) indices

The index number approach, generally, does not proceed by specifying an explicit production (or a dual cost) function; rather its strategy is to compute separate input and output indexes from observed prices and quantity data and use them for measurement of TFP. As a result of this, TFP by this approach is free from all the biases of explicit functional form. Multifactor productivity growth may be defined as the difference between the growth in output and the growth in aggregate inputs. The multi-factor productivity is known as total factor productivity otherwise.

$TFPDM = \sqrt{PFPL \times PFPK}$ = Total factor productivity measured by direct method

PFPL (NVA/L) = Partial factor productivity of labour

PFPK (NVA/K) =Partial factor productivity of capital

c. Cobb-Douglas production function

Production function approach to productivity measurement is more advantageous because it can handle the problems arising due to non- separability of inputs and output, non-neutral technical change, non-constant returns to scale and non- proportionality of input prices of their respective marginal productivity in a explicit manner. A production function shows the technological relationship between the maximum output obtainable from a given set of inputs and the relationship between the inputs themselves in the existing state of relationship between the inputs themselves in the existing state of technological change. In this approach to productivity measurement the various components of productivity can be estimated directly by econometric estimation. The production function can be used to measure the efficiency of production technology, returns to scale, the degree of economies to scale, the degree of capital intensity of technology and the degree of substitution between factors of production.

One of the most commonly estimated functional forms in the Cobb-Douglas production (C-D) function written as:

$$V = A\,(t)\,K^{\alpha}\;\; L^{\beta}\;\; e^{u}$$

Where α and β are coefficient of labour and capital, A (t) is the efficiency parameter and u is the stochastic disturbance term following usual properties. Before the production function can be estimated some functional form has to be given to the term a (t). The most commonly used in practice has been $A\,(t) = Ae^{\lambda t}$ where λ is the measure of technical change in output per period [λ measures the proportionate change in output per period when input level are held constant]. It is very important here to Point out the limitations of this representation of technical change. It assumes neutral technical progress and that the technical progress is exogenous and disembodied (this neglects the usefulness of investment for technical progress).

This function is linear in the logarithmic of the inputs, output and time. Thus, we have:

$$\text{Ln } V = a + \alpha\,\text{LnL} + \beta\text{LnK} + \lambda t + \mu_i$$

The estimation of this equation yields values of α, β, and λ,λ provides estimates of TFPG and is the rate of exponential technological change. Sum of the partial elasticities ($\alpha + \beta$) indicates the extent of economies or diseconomies to scale. The returns to scale are constant, increasing or decreasing if the value of $\alpha + \beta$ is equal to unity, more than unity or less than unity respectively.

Marginal product of labour (MPL) and capital (MPK) can be obtained by applying the following formula

$$MP_L = \delta V/\delta L = \alpha V/L$$

$$MP_K = \delta V/\delta K = \beta V/K$$

Since profit maximization entails that marginal productivity of labour is equal to the real wage rate and marginal product of capital is the price per unit of capital, it would imply that:

$$MP_L = w/p = \alpha V/L.$$

share of labour in total output is:

$$\alpha = (w/p).(L/V).$$

similarly

$$MP_L = r/p = (K/L).$$

$$MP_k = r/p = (k/v)$$

and share of capital in total output is

$$\beta = (r/p).(K/V)$$

$$MRS_{LK} = MP_L / MP_K$$

d. Employment Elasticity

Employment elasticity was estimated using the following regression equation.

$$\text{In } L_t = \alpha_0 + \alpha_1 \ln Y_t + \alpha_2 \ln K_t$$

Where, L_t = Number of person engaged in the current period

Y_t = Net value added in the current period

K_t = Fixed capital in the current period

α_0 = Constant co-efficient

α_1 = Elasticity of employment with respect to net value added

α_2 = Elasticity of employment with respect to fixed capital

$\alpha_2 > 0$ = implies of employment and capital are complements

$\alpha_2 < 0$ = implies of employment and capital are substitutes.

e. Output Elasticity

The elasticity of output with respect to employment of labour and fixed capital measures the change in output due to change in one unit of labour or change in one unit of capital. The output elasticities were estimated as follows:

Where, $\ln Y_t = \beta_0 + \beta_1 \ln L_t + \beta_2 \ln K_t$

Lt = Number of person engaged in the current period

Y_t = Net value added in the current period

K_t = Fixed capital in the current period

β_0 = Constant co-efficient

β_1 = Elasticity of employment with respect to labour

β_2 = Elasticity of employment with respect to capital

f. Wage Elasticity

The wage elasticity with respect to labour productivity and net value added measures the change in wage rate due to change in one unit of the below mentioned variables. The elasticity can be estimated by testing the following regression equation.

$$W_t = b_0 + b_1 \ln L_{pt} + b_2 \ln y_t$$

W_t = Wage rate in the current period

Lp_t = Labour productivity in the current period

Y_t = Net value added in the current period

b_0 = Constant Co-efficient

b_1 = Elasticity of wage with respect to labour productivity

b_2 = Elasticity of wage with respect to net value added

g. Compound Annual Growth Rate (CAGR)

In the present study, compound annual growth rate of total factor productivity, labour productivity and capital productivity was calculated. Symbolically it is represented as follows:

$$Y = ab^t$$

Where, Y = is the dependent variable (i.e. total factor productivity, labor & capital productivity, t = is the independent variable (i.e. time period) a&b are the parameters. After getting b (coefficient) the following method is being used to estimate CAGR

$$CAGR = [\text{Antilog } p - 1] \times 100.$$

5. Limitations

One of the limitations of the present study is that the study period is restricted up to 2010-11 based on the availability of data during the period when the analysis was done. The findings and conclusions emerging out of this study may not suit the other reference periods.

RESULTS AND DISCUSSION

IV. RESULTS AND DISCUSSION

The results of the current study are discussed under the heads:

1. Measurement of technical progress
2. Analysis of partial and total factor productivity indices
3. Analysis of elasticities – employment, output and wage
4. Estimation of production function

1. Measurement of technical progress

The technical progress of the industries were analyzed by calculating Marginal Productivity Labour (MP_L), Marginal Productivity of Capital (MP_K), Marginal Rate of Substitution of labour for capital ($MRTS_{LK}$) Marginal productivity or coefficient of capital (MRS_{LK}) and capital may be defined as the ratio between a change in output in a given economy of industry for a given time period and change in gross block of that economy. Marginal Productivity of Labour (MP_L) may be defined as the ratio between a change in output in a given economy or industry for a given period and change in amount of labour use. The $MRTS_{LK}$ explains the rate at which substitution was taken place between labour and capital.

a. Growth of MP_K ratios

The trends in the growth of marginal productivity of capital (MP_K) ratio is presented in table-1

TABLE -1

TRENDS IN MARGINAL PRODUCTIVITYOFCAPTIAL (MP_K) RATIOS

Industries / Year	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11		σ	C.V
CHEMICAL&CHEMICAL PRODUCTS	1.215	1.5220	1.5731	1.9000	1.6496	1.6471	1.8140	1.4434	1.6972	1.7626	1.6224	.1873	11.5461
BASIC METALS	.411	.5957	.7540	1.2151	.8484	1.0815	1.2677	.8192	.5417	.5764	.8111	.2799	34.5151
NON-METALLIC MINERAL PRODUCTS	1.054	1.1132	1.1316	1.4776	1.4978	2.2865	2.4884	2.2721	2.1774	1.4627	1.6961	.5246	30.9290
COKE,REFIND PETROLEUM PRODUCTS AND NUCLEAR FUEL	.085	.1848	.1939	.2921	.3523	.4078	.4876	.4841	.2284	.2696	.2986	.1266	42.4052
MOTOR VEHICLES, TRAILERS AND SEMI-TRAILERS	1.246	1.8265	2.7796	3.1880	4.1221	3.4601	2.4980	1.4476	1.9522	1.8200	2.4340	.8920	36.6485
RUBBER &PLASTIC PRODUCTS	.923	.9592	1.0188	.8687	1.0700	.9705	1.2443	1.4040	1.3104	1.5607	1.1330	.2209	19.4943
FABRICATED METAL PRODUCTS	.057	.0560	.0664	.0747	.0825	.0829	.0709	.0640	.0731	.0657	.0693	.0088	12.7650
MACHINERY & EQUIPMENT N.E.C.	.606	.5032	.6170	.7011	.7288	.8491	.8333	.9251	.8348	.7169	.7315	.1243	16.9899
ELECTRICAL MACHINERY AND APPARATUS N.E.C.	.417	.3907	.5067	.6445	.7901	1.0141	.8774	.6721	.6174	.5721	.6502	.1880	28.9210
TRANSPORT EQUIPMENT	.616	.6741	.7414	.7815	.8147	.8782	.6764	.6542	.6857	.7380	.7260	.0765	10.5373
	.663	.7825	.9383	1.1143	1.1956	1.2678	1.2258	1.0186	1.0118	.9545			
Σ	.4118	.5423	.7425	.8590	1.0712	.9298	.7757	.5985	.6936	.6066			
C.V	62.1131	69.2964	79.1419	77.0877	89.5970	73.3436	63.2792	58.7630	68.5504	63.5518			

Source: Calculations are based on ASI data

The MP_K ratios of various high technology industries in India during the reference period of the study show that MP_K was positive in all the industries. This shows that capital contributed positively to output. Also MP_K ratios during the period shows that among the high technology industries on an average manufacture of motor vehicles, trailers and semi-trailers has recorded the maximum capital productivity of (2.4340) and minimum by manufacture of fabricated metal product (0693). The variations in MP_K ratios might be due to wage differentials across the high technology industries. Across the years it was found that MP_K was maximum in the year 2005-06 and minimum during the beginning of the reference period.

b. Growth of MP_L ratios

The trends in the growth of marginal productivity of labour (MP_L) ratio is presented in table-2

TABLE-2

TRENDS INMARGINAL PRODUCTIVITYOFLABOUR (MP_L) RATIOS

Year / Industries	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11		σ	C.V
CHEMICAL&CHEMICAL PRODUCTS	.303	.3420	.3803	.4242	.4600	.4780	.5353	.5768	.6523	.6784	.4830	.1205	400.8346
BASIC METALS	.944	1.3939	1.9464	3.3785	2.6447	3.2357	3.5570	2.5458	2.8053	2.3332	2.4785	.8075	306.9243
NON-METALLIC MINERAL PRODUCTS	.788	.5487	.8373	1.0460	1.0131	1.4519	2.1244	2.1183	2.2865	1.7233	1.3938	.6020	231.5112
COKE,REFIND PETROLEUM PRODUCTS AND NUCLEAR FUEL	2.657	6.2347	8.0454	9.1292	11.9669	13.6022	13.7912	14.1807	11.8489	16.5502	10.8006	4.0160	268.9381
MOTOR VEHICLES,TRAILERS AND SEMI-TRAILERS	3.414	4.0405	5.9233	6.9256	8.9167	7.5736	7.0827	5.6481	7.4357	7.2019	6.4162	1.5951	402.2518
RUBBER&PLASTIC PRODUCTS	.819	.8858	.9126	.9196	.8866	.8940	1.2733	1.6082	1.7037	2.2060	1.2109	.4509	268.5197
FABRICATED METAL PRODUCTS	2.041	2.0602	2.4225	2.5223	3.2152	4.0124	4.3320	4.5820	5.3868	6.2700	3.6844	1.3935	264.4051
MACHINERY & EQUIPMENT N.E.C.	1.61	1.4825	1.8214	2.0125	2.4894	2.7702	3.2528	4.2407	4.6191	4.3673	2.8666	1.1326	253.0872
ELECTRICAL MACHINERY AND APPARATUS N.E.C.	2.768	3.3089	3.7684	4.0479	5.4352	7.4667	7.4634	7.4357	7.4570	7.7424	5.6894	1.9325	294.4048
TRANSPORT EQUIPMENT	1.204	1.3429	1.5447	1.7954	2.0067	2.1594	2.0906	2.3733	3.1711	3.4462	2.1134	.6944	304.3546
	1.6548	2.1640	2.7602	3.2201	3.9035	4.3644	4.5503	4.5310	4.7366	5.2519			
σ	.9734	1.7524	2.3423	2.6678	3.5981	3.8690	3.7657	3.7615	3.2213	4.4034			
C.V	58.8235	80.9776	84.8600	82.8467	92.1785	88.6490	82.7578	83.0166	68.0091	83.8444			

Source: Calculations are based on ASI data

MP_L ratios across major high technology industries of India showed that during the period as a whole it was maximaum in the manufacture of coke, refined petroleum products and nuclear fuel. On the other hand across the period it had shown gradual increase from the beginning of the period to the end of the period. Excepting the initial period the average ratio recoded more than 2 fold during the reference period under study. But the magnitude of variability was more than 80 percent, implying the fact that the growth was instable.

C. Growth of $MRTS_{LK}$ ratios

The trends in the growth of marginal productivity of labour ($MRTS_{LK}$) ratio is presented in table-3

TABLE-3

TRENDS IN MARGINAL RATE OF TECHNICAL SUBSTUTION (MRTS $_{LK}$) OF LABOUR FOR CAPITAL

Year / Industries	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11		σ	C.V
CHEMICAL& CHEMICAL PRODUCTS	.2494	.2247	.2418	.2233	.2789	.2902	.2951	.3996	.3843	.3849	.2972	.0650	21.8624
BASIC METALS	2.2968	2.3399	2.5814	2.7804	3.1173	2.9919	2.8059	3.1077	5.1787	4.049	3.1248	.8310	26.5943
NON-METALLIC MINERAL PRODUCTS	.7476	.4929	.7399	.7079	.6764	.6350	.8539	.9323	1.0501	1.172	.8014	.1943	24.2477
COKE,REFIND PETROLEUM PRODUCTS AND NUCLEAR FUEL	31.2588	33.7376	41.4925	31.2537	33.9679	33.3551	28.2838	29.2929	51.8778	61.3880	37.5908	10.3310	27.4827
MOTOR VEHICLES, TRAILERS AND SEMI-TRAILEARS	2.7400	2.2122	2.1310	2.1724	2.1631	2.1888	2.8353	3.9017	3.8089	3.9587	2.8112	.7446	26.4860
RUBBER&PLASTIC PRODUCTS	.8873	.9235	.8958	1.0586	.8286	.9212	1.0233	1.1454	1.3001	1.4135	1.0397	.1831	17.6134
FABRICATED METAL PRODUCTS	35.8070	36.7893	36.4834	33.7657	38.9721	48.4005	61.1001	71.5938	73.6908	95.4338	53.2037	21.1463	37.8664
MACHINERY & EQUIPMENT N.E.C.	2.6568	2.9461	2.920	2.8705	3.4158	3.2625	3.9035	4.5840	5.5332	6.0919	3.8184	1.1397	29.8480
ELECTRICAL MACHINERY AND APPARATUS N.E.C.	6.6379	8.4692	7.4371	6.2807	6.8791	7.3629	8.5063	11.0634	12.0781	13.5333	8.8248	2.3895	27.0770
TRANSPORT EQUIPMENT	1.9545	1.9921	2.0835	2.2974	2.4631	2.4589	3.0908	3.6278	4.6246	4.6696	2.9262	.9899	33.8275
	8.5236	9.0128	9.7006	8.3411	9.2762	10.1867	11.2698	12.9649	15.9527	19.2100			
σ	12.6565	13.3239	14.8069	12.1995	13.7580	15.8223	18.3794	21.1818	24.1224	30.7628			
C.V	148.4874	147.8343	152.638	146.258	148.3149	155.3235	163.0857	163.3782	151.2126	160.1399			

Source: Calculations are based on ASI data

It is evident that $MRTS_{LK}$ ratios during the period under study were positive across the years and across the industries. Excepting manufacture of chemical and chemical products all the ratios recorded more than a unit ratio with variations, indicating differences in the marginal productivity ratios of labour and capital.

2. Analysis of partial and total factor productivity

a. **Partial factor productivity of Labour** (PFPL)

The trends in the growth of partial factor productivity of labour (PFPL) indices is presented in table-4

TABLE-4

TRENDS INPARTIAL FACTOR PRODUCTIVITY INDICES OFLABOUR (PFPL)

Industries \ Year	2001-02	2002-03	2003-04	2004- 05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	Constant (A)	Parameter (β)	R^2
CHEMICAL&CHEMICAL PRODUCTS	100	113	126	140	152	158	177	190	215	224	95.108*** (56.095)	8.8** (30.708)	.992
BASIC METALS	100	148	206	358	280	343	377	270	297	247	150.039* (4.277)	8.9** (2.368)	.412
NON-METALLIC MINERAL PRODUCTS	100	70	106	133	129	184	270	269	290	219	71.432* (6.515)	14.6* (5.915)	.814
COKE,REFIND PETROLEUM PRODUCTS AND NUCLEAR FUEL	100	235	303	344	450	512	519	534	446	623	158.412* (4.796)	15.2* (4.535)	.720
MOTOR VEHICLES,TRAILERS AND SEMI-TRAILERS	100	118	174	203	261	222	207	165	218	211	126.794* (6.071)	6.5* (2.437)	.426
RUBBER&PLASTIC PRODUCTS	100	108	111	112	108	109	155	196	208	269	78.015* (9.006)	10.5* (5.866)	.811
FABRICATED METAL PRODUCTS	100	101	119	124	158	197	212	225	264	307	81.146*** (23.609)	13.2*** (19.386)	.979
MACHINERY & EQUIPMENT N.E.C.	100	92	113	125	155	172	202	263	287	271	77.073*** (16.036)	13.8*** (13.692)	.959
ELECTRICAL MACHINERY AND APPARATUS N.E.C.	100	120	136	146	196	270	270	269	269	280	97.100*** (10.027)	12.4* (7.727)	.882
TRANSPORT EQUIPMENT	100	112	128	149	167	179	174	197	263	286	91.051*** (20.594)	11*** (14.035)	.961

Source: Calculations are based on ASI data

Foot Note: *Significant at 1% level

****Significant at 5% level**

*****Significant at 10% level**

Industry- wise growth of labour productivity indices shows that from the beginning of the period to the end of the period it was maximum for the manufacture coke and refined petroleum products and nuclear fuel (6.23 fold), followed by fabricated metal products (3.07 fold), transport equipment (2.86 fold), electrical machinery and apparatus (2.80 fold), machinery and equipment (2.71 fold), rubber and plastic products (2.69 fold), basic metals (2.47 fold), chemical and chemical products (2.24 fold), other non–metallic mineral products (2.19 fold), motor vehicles, trailers and semi-trailers (2.11 fold). The annual trend rates calculated revealed that labour productivity growth rate was statistically significant for all the high technology industries. It ranged between 6.5 percent and 15.2 percent across the type of industries. The significant growth rate of labour productivity in all the industries might be due to reduction in working time, high minimum wage which stimulates labourers to work more in less time, keeping less productive persons out of employment and advancement in technology. The co-efficient of determination (R^2) ranged between 0.412 and 0.992 across the industries. The maximum R^2 was recorded for the manufacture of chemical and chemical products implying the fact that more than ninety percent (99.2 percent) of the variation in the growth of labour productivity in this industry was due to the influence institutional factors and the remaining 0.8 percent was incidental.

a. **Partial factor productivity of capital** (PFPK)

The following table-5 provides details regarding the partial factor productivity of capital.

TABLE-5

TRENDS IN PARTIAL FACTOR PRODUCTIVITY INDICES OF CAPITAL (PFPK)

Industries / Year	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	Constant (A)	Parameter (β)	R^2
CHEMICAL&CHEMICAL PRODUCTS	100	125	129	156	136	136	149	119	140	145	117.580*** (12.563)	2.2 (1.699)	.265
BASIC METALS	100	145	183	296	206	263	308	199	132	140	166.976* (3.747)	1.9 (.444)	.024
NON-METALLIC MINERAL PRODUCTS	100	106	107	140	142	217	236	216	207	139	98.902* (6.090)	8.6 (3.012)	.531
COKE,REFIND PETROLEUM PRODUCTS AND NUCLEAR FUEL	100	217	228	344	314	480	574	570	269	317	165.456* (3.446)	11.2** (2.388)	.416
MOTOR VEHICLES, TRAILERS AND SEMI-TRAILERS	100	147	223	256	331	278	200	116	157	146	184.471* (3.523)	-.2.4 (-.042)	.000
RUBBER&PLASTIC PRODUCTS	100	104	110	94	116	105	135	152	142	169	87.769*** (14.526)	5.8* (5.193)	.771
FABRICATED METAL PRODUCTS	100	98	117	131	145	145	124	112	128	115	109.969*** (10.948)	1.7 (1.130)	.138
MACHINERY & EQUIPMENT N.E.C.	100	83	102	116	120	140	138	153	138	118	91.869*** (11.226)	4.7 (3.272)	.572
ELECTRICAL MACHINERY N.E.C.	100	94	122	155	189	243	210	161	148	137	112.428* (5.270)	5.2 (1.696)	.265
TRANSPORT EQUIPMENT	100	109	120	127	132	143	110	106	111	120	114.082*** (12.665)	.5 (.379)	.018

Source: Calculations are based on ASI data

Foot Note: *Significant at 1% level

****Significant at 5% level**

*****Significant at 10% level**

Across the industries, the growth of partial factor productivity of capital was maximum (3.17 fold) in the manufacture of coke and refined petroleum products with the trend rate of 11.2 percent. Whereas the remaining high technology manufacturing sector had shown the growth varying between (1.15 fold) and (1.69 fold). Across the time period it ranged between (1.09 fold) and (1.43 fold) from the beginning of the period to the end of the period. Excepting the manufacture of motor vehicles trailers and semi-trailers all the industries recorded positive rates.

C. **Total factor productivity (TFP) growth**

The following table-6 provides details regarding the total factor productivity of high technology industries in India during the reference period under study.

TABLE-6

TRENDS IN TOTAL FACTOR PRODUCTIVITY (TFP) INDICES

Industries / Year	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	Constant (A)	Parameter (β))	R^2
CHEMICAL&CHEMICAL PRODUCTS	100	119	127	148	144	147	162	150	173	180	105.840*** (21.367)	5.5* (7.258)	.868
BASIC METALS	100	146	194	326	240	300	341	232	198	186	158.072* (4.051)	5.4 (1.367)	.189
NON-METALLIC MINERAL PRODUCTS	100	86	106	136	135	200	252	241	245	174	83.869* (6.695)	11.3* (4.699)	.734
COKE,REFIND PETROLEUM PRODUCTS AND NUCLEAR FUEL	100	226	263	344	376	246	546	552	346	444	154.623* (4.231)	12.8* (3.351)	.584
MOTOR VEHICLES, TRAILERS AND SEMI-TRAILERS	100	132	197	228	294	248	203	138	185	176	153.107* (4.480)	3.1 (.868)	.086
RUBBER&PLASTIC PRODUCTS	100	106	110	103	112	107	145	173	172	213	82.720*** (11.898)	8.1* (6.012)	.819
FABRICATED METAL PRODUCTS	100	99	118	127	151	169	162	159	184	188	94.181*** (19.016)	7.5* (8.834)	.907
MACHINERY & EQUIPMENT N.E.C.	100	87	107	120	136	155	167	201	199	179	83.825*** (14.399)	9.3* (8.288)	.896
ELECTRICAL MACHINERY N.E.C.	100	106	129	150	192	256	238	208	200	196	104.314* (7.134)	8.8* (3.907)	.656
TRANSPORT EQUIPMENT	100	110	124	138	148	160	138	145	171	185	101.797*** (17.874)	5.7* (6.375)	.836

Source: Calculations are based on ASI data

Foot Note: *Significant at 1% level

****Significant at 5% level**

*****Significant at 10% level**

The total factor productivity indices were found to be increasing from the beginning of the period in all the high technology industries and during the reference period. But the estimated growth rate of manufacture of basic metals and motor vehicles, trailers and semi-trailers were statistically insignificant. The varying levels of magnitude of total factor productivity trends explained the fact that across the industries the significant growth rate might be due to the provision of better infrastructural facilities available to these industries.

3. Analysis of Elasticities

a. Employment elasticity

The following table-7 provides details regarding employment elasticity prevailing in the high technology industries in India.

TABLE-7

EMPLOYMENT ELASTICITY CO-EFFICIENTS

INDUSTRIES	Constant (A)	Y_t	K_t	R^2	DW-statistic	F-value
CHEMICAL&CHEMICAL PRODUCTS	108.527* (4.170)	.269 (1.048)	-.425 (-.914)	.136	.854	.552
BASIC METALS	54.290* (3.576)*	.100 (2.019)	.271* (3.536)	.910	2.683	35.604
NON-METALLIC MINERAL PRODUCTS	80.376* (7.319)	.069 (1.126)	.266*** (1.988)	.857	2.882	21.058
COKE,REFIND PETROLEUM PRODUCTS AND NUCLEAR FUEL	77.342* (7.719)	.084* (4.490)	.060 (.791)	.884	1.837	26.581
MOTOR VEHICLES,TRAILERS AND SEMI-TRAILERS	56.0032*** (11.547)	.170* (7.155)	.316* (9.706)	.993	2.180	488.670
RUBBER&PLASTIC PRODUCTS	59.254* (4.340)	.000 (-.004)	.463*** (1.940)	.960	1.053	84.911
FABRICATED METAL PRODUCTS	84.784*** (16.000)	.383* (4.008)	-.176 (-1.557)	.979	1.307	164.082
MACHINERY & EQUIPMENT N.E.C.	84.868*** (13.774)	.157 (2.016)	.027 (.237)	.927	1.660	44.145
ELECTRICAL MACHINERY AND APPARATUS N.E.C.	59.113*** (16.758)	.112* (3.819)	.198* (4.486)	.986	1.930	250.630
TRANSPORT EQUIPMENT	86.844*** (16.321)	.377* (3.655)	-.239*** (-1.978)	.919	1.342	39.975

Source: Calculations are based on ASI data

Foot Note: *Significant at 1% level

****Significant at 5% level**

*****Significant at 10% level**

Employment elasticity with respect to net value added (y_t) in all the high technology industries was positive. On the other hand the elasticity co-efficient in relation to fixed capital (K_t) was positive in 7 out of 10 industries under study. From the table it is very clear that the negative elasticities with respect fixed capital in the manufacture of chemical and chemical products, fabricated metal products and transport equipment implies that fixed capital used to be substitute for labour to a larger extent across the industries during the reference period under study.

b. Output elasticity

The following table-8 provides details regarding output elasticity across the major high technology industries in India.

TABLE-8

OUTPUT ELASTICITY CO-EFFICENTS

INDUSTRIES	Constant (A)	L_t	K_t	R^2	DW-statistics	F -value
CHEMICAL&CHEMICAL PRODUCTS	-83.965 (-1.436)	.504 (1.048)	1.622* (5.802)	.834	1.654	17.530
BASIC METALS	-101.499 (-.673)	3.697 (2.019)	-.234 (-.303)	.754	1.302	10.719
NON-METALLIC MINERAL PRODUCTS	-207.826 (-1.258)	2.217 (1.126)	1.043 (1.208)	.815	1.373	15.465
COKE,REFIND PETROLEUM PRODUCTS AND NUCLEAR FUEL	-652.270 (-3.312)	8.797* (4.490)	.217 (.271)	.875	1.963	24.405
MOTOR VEHICLES, TRAILERS AND SEMI-TRAILERS	-275.342* (-4.652)	5.168* (7.155)	-1.495* (3.892)	.968	2.272	104.194
RUBBER&PLASTIC PRDOUCTS	-97.424 (-1.364)	-.005 (-.004)	1.914* (3.510)	.978	2.971	155.202
FABRICATED METAL PRODUCTS	-149.884* (-3.539)	1.817* (4.008)	.674* (5.269)	.994	2.173	614.560
MACHINERY & EQUIPMENT N.E.C.	-214.846 (-2.236)	2.334 (2.016)	.822** (2.708)	.964	1.833	93.299
ELECTRICAL MACHINERY AND APPARATUS N.E.C.	-347.854* (-3.426)	6.037* (3.819)	-.742 (1.292)	.957	1.400	77.711
TRANSPORT EQUIPMENT	-148.962* (-3.394)	1.739* (3.655)	.810* (7.692)	.987	1.074	259.498

Source: Calculations are based on ASI data

Source: Calculations are based on ASI data

Foot Note: ***Significant at 1% level**

****Significant at 5% level**

The output elasticity with respect to employment (L_t) showed that excepting manufacture of rubber and plastic product and chemical and chemical products, more than a unit increase was brought in all the high technology industries which was considered to be statically significant. Output elasticity with respect to fixed capital (K_t) revealed that more than unit change with statistically significance was noted in the manufacture of chemical and chemical products, rubber & plastic products. Inverse relationship could be observed in 3 out of 10 industries. The co-efficient of R^2 in all the high technology industries was high, explained the fact that the fit was good.

b. Wage elasticity

The following table-9 provides details regarding wage elasticity in the industries which are included for the study.

TABLE-9

WAGE ELASTICITY CO-EFFICIENTS

INDUSTRIES	Constant (A)	Y_t	Lp_t	R^2	DW–statistics	F - value
CHEMICAL&CHEMICAL PRODUCTS	41.872* (3.830)	-.183 (-1.465)	.668 (5.834)	.917	1.363	38.513
BASIC METALS	111.624*** (16.002)	.088* (5.827)	-.134* (-3.542)	.835	1.438	17.759
NON-METALLIC MINERAL PRODUCTS	98.958* (9.741)	.293* (3.638)	-.370 (-2.238)	.865	2.475	22.390
COKE,REFIND PETROLEUM PRODUCTS AND NUCLEAR FUEL	84.836* (3.362)	.099 (1.247)	-.073 (-.458)	.526	1.019	3.882
MOTOR VEHICLES, TRAILERS AND SEMI-TRAILERS	107.460*** (31.155)	.112*** (16.258)	-.183* (-7.310)	.978	1.832	154.912
RUBBER&PLASTIC PRODUCTS	131.627* (5.505)	.452 (3.097)	-729*** (-1.943)	.948	2.629	64.374
FABRICATED METAL PRODUCTS	113.089* (5.108)	.236** (2.888)	-.366 (-1.360)	.943	1.774	58.266
MACHINERY & EQUIPMENT N.E.C.	63.811* (5.553)	.036 (.349)	.274 (1.371)	.946	.815	61.680
ELECTRICAL MACHINERY AND APPARATUS N.E.C.	116.246*** (10.220)	.195* (4.481)	-.179 (-1.730)	.892	1.546	28.846
TRANSPORT EQUIPMENT	49.117 (3.082)	-.051 (-.428)	.488 (2.031)	.930	2.136	40.041

Source: Calculations are based on ASI data

Foot Note: *Significant at 1% level

****Significant at 5% level**

*****Significant at 10% level**

Wage elasticity with respect to labour productivity (Lp_t) showed mixed trend where as manufacture of chemical and chemical products showed negative relationship with net value added (Y_t). The co-efficient of determination R^2 calculated for all the industries in all the periods explained the fact that the fit was good. The contribution of the independent variables over influencing dependent variable was high. Only negligible percent of change would be brought about by related variables.

4. Estimation of production function

The following table-10 provides details regarding factor intensity and return to scale of selected industries based on Cobb-Douglas production function.

TABLE-10

CO-EFFICIENTS OF PRODUCTION FUNCTION

INDUSTRIES	Constant (A)	β1	β2	S	R^2	DW-Statistics	β1/S	β2/S
CHEMICAL&CHEMICAL PRODUCTS	.927 (1.045)	1.215* (5.072)	.303 (.840)	1.518	.789	1.4411	80	20
BASIC METALS	.435 (.367)	.411 (.485)	.944 (.704)	1.355	.719	.706	30	70
NON-METALLIC MINERAL PRODUCTS	1.614 (1.523)	1.054 (2.254)	.788 (.916)	1.842	.862	.928	57	43
COKE,REFIND PETROLEUM PRODUCTS AND NUCLEAR FUEL	3.152** (2.600)	.085 (.160)	2.657** (2.961)	2.742	.787	1.154	3	97
MOTOR VEHICLES,TRAILERS AND SEMI-TRAILERS	2.341* (6.064)	1.246* (5.037)	3.414* (8.589)	4.66	.968	2.440	27	73
RUBBER&PLASTIC PRODUCTS	1.486** (2.688)	.923** (2.349)	.819 (1.272)	1.742	.979	2.606	53	47
FABRICATED METAL PRDOUCTS	2.191* (6.467)	.057 (.375)	2.041* (6.545)	2.098	.996	2.833	3	97
MACHINERY & EQUIPMENT N.E.C.	2.424** (2.627)	.606*** (1.898)	1.610 (2.124)	2.216	.969	1.969	27	73
ELECTRICAL MACHINERY AND APPARATUS N.E.C.	2.488** (2.362)	.417 (.664)	2.768** (2.468)	3.185	.895	.894	13	87
TRANSPORT EQUIPMENT	1.597 (3.069)	.616* (4.569)	1.204 (3.224)	1.82	.981	1.112	34	66

Source: Calculations are based on ASI data

Foot Note: *Significant at 1% level

****Significant at 5% level**

*****Significant at 10% level**

Efficiency parameter ‘A’ or the organisational efficiency was positive in all the industries. This implied that the contribution of entrepreneurship to output was positive. Capital co- efficient β1 was positive in all the high technology industries which implied that there existed positive relationship between output and capital. Wage co-efficient β2, was also positive and statistically significant for the manufacture of coke, refined petroleum products and nuclear fuel, motor vehicles, trailers and semi-trailers, fabricated metal products, machinery and equipment **n.e.c.**, electric machinery and apparatus n.e.c. and transport equipment industry. This implied that there existed positive relationship between inputs - output and wages in these industries. The sum of co-efficients β1and β2 shows increasing returns to scale in all the high technology industries. It was also surprising to note that the R^2 was high in all the industries. The percentage share of factor inputs presented indicated that the percentage share of wage was higher, varied between 20 percent and 97 percent. It was maximum for fabricated metal products (97 percent). With regard to type of technology adopted by the industries it could be observed that industries were adopting both labour intensive as well as capital intensive technology since the co-efficient of capital and wage were mixed .

SUMMARY AND CONCLUSION

V. SUMMARY AND CONCLUSION

It is widely accepted that the high-technology sector is one of the most dynamic parts of any economy. High-tech industries are thought of as an important source of employment growth, profits, and innovation in products and production processes. Accordingly, the high-tech sector has been a center of interest, generating numerous analyses and studies. In a 1997 Monthly Labor Review study, William Luker, Jr., and Donald Lyons stated that “the continuing attention paid to high-tech industries in recent years seems to be rooted in the widespread belief that the innovations they produce can profoundly alter an economy’s mix of firms, industries, and jobs.

The Organization for Economic Cooperation and Development (OECD) identifies high-tech industries largely on the basis of their level of research and development intensity (research and development expenditure in relation to value added). In his 1999 study of high-tech employment, Daniel Hecker notes that high-tech firms “devote a ‘high’ proportion of expenditures to research and development and employ a ‘high’ proportion of scientific, technical, and engineering personnel.” The various approaches to classifying high-tech industries fall into two broad classes: A majority of studies classify industries by the extent to which they employ certain types of workers or undertake certain types of expenditures (input-based criteria), while another group of studies focuses on the nature of the industries’ products (output based criteria). Both approaches have certain advantage as well as drawbacks. Input-based approaches have the advantage of resting on easily obtainable, non subjective data—for example, the proportion of an industry’s workers in technology-oriented professions or the proportion of industry costs devoted to research and development.

In the absence of wide agreement on the threshold proportions above which an industry should be considered high tech, however, any such choice must be considered arbitrary. Input-based approaches also suffer from a failure to take account of the products of the industry. Thus, high-tech industries identified solely on the basis of inputs may chiefly manufacture products not commonly thought of as high tech. Output-based approaches generally rely on some determination of the level of technical sophistication embodied in an industry’s products or the extent to which these products have undergone rapid change. Although following this approach makes it more likely that the products of the designated industries will match popular conceptions of high tech, the judgments about product sophistication or rapid change on which these studies rely tend to be subjective.

Labour productivity relates output to the labor resources used in its production. It is an Indicator of the efficiency with which labour is being utilized. High-tech manufacturing strong performance seems consistent with expectations, but the situation deserves a closer look. Economic growth can occur from increases in inputs or from advances in productivity. Increases in inputs impose costs on society, such depletion of resources. Multifactor productivity growth measures changes in output that are not attributed to the changes in combined inputs. While measures of labor productivity provide valuable insights into efficiency, measures of multifactor productivity are more useful in this regard. By accounting for sources of growth from additional inputs—specifically, capital and intermediate purchases— multifactor productivity analysis more closely measures changes in efficiency. The high-tech manufacturing industries do indeed share several key characteristics and tendencies. The most striking commonality is the tendency of high-tech industries to have more rapid rates of growth in the ratios of intermediate purchases to labor and capital to labor than do the non-high-tech industries. Conversely, hours in the high-tech industries tended to decline more rapidly than (or not to grow as quickly as) hours in the non-high-tech industries. Another feature of high-tech industries is their tendency to outperform non-high-tech manufacturing industries in output per hour and unit labor costs. Output per hour is more likely to grow more rapidly, and unit labor costs are more likely to grow more slowly (or decline more rapidly) in high-tech industries than in other manufacturing industries.

In view of the above points this study was under taken with the following objectives;

1. Anlayse different types of elasticities-output, employment and wage elasticity

2. Estimate marginal, partial and total factor productivity indices along with their annual trend rates

3. Examine the returns to scale and factor intensity

Net Value Added (NVA) was taken as output, since trends are not affected significantly by the use of net value added. Also ambiguity in the calculation of depreciation can be overcome if net value added is taken as a measure of output. Labour input consisted workers directly involved in production the fixed capital was taken into account as capital input. Wages included remuneration paid to workers. The basic data source of the study was Annual Survey of Industries (ASI) published by Central Statistical Organization (CSO), Government of India covering the period from 2001-02 to 2010-11.All the referred variables were normalized by applying Gross Domestic Product (GDP) deflator. The GDP at current and constant prices were obtained by referring to Economic Survey, published by Government of India, Ministry of Finance and Economic Division, New Delhi. Partial factor productivity indices, Total factor productivity (TFP) indices Cobb-Douglas production function, Compound Annual Growth Rate (CAGR) and regression models were used to analyse the data the results are summarized below

- MP_K was positive in all the industries. This showed that capital contributed positively to output. Also MP_K ratios during the period showed that among the high technology industries on an average manufacture of motor vehicle had recorded the maximum capital productivity (2.4340) and minimum by manufacture of fabricated metal products (0693).
- MP_L ratios across major high technology industries of India showed that during the period as a whole it was maximum in the manufacture of coke, refined products and nuclear fuel. On the other hand across the period it had shown gradual increase from the beginning of the period to the end of the period. Excepting the initial period, the average ratio recorded more than 2 fold during the reference period under study. But the magnitude of variability was more than 80 percent, implying the fact that the growth was instable.
- MR_{TSLK} ratios during the period under study were positive across the years and across the industries. Excepting manufacture of chemical and chemical products all the ratios recorded more than a unit ratio with variations, indicating differences in the marginal productivity ratios of labour and capital.
- Industry- wise growth of labour productivity indices showed that from the beginning of the period to the end of the period it was maximum for the manufacture coke and

refined petroleum products and nuclear fuel (6.23 fold), followed by fabricated metal products (3.07 fold), transport equipment (2.86 fold), electrical machinery and apparatus (2.80 fold), machinery and equipment n.e.c. (2.71 fold), rubber and plastic products (2.69 fold), basic metals (2.47 fold), chemical and chemical products (2.24 fold), other non –metallic mineral products (2.19 fold),motor vehicles, trailers and semitrailers (2.11 fold).

- The annual trend rates calculated revealed that labour productivity growth rate was statistically significant for all the high technology industries. It ranged between 6.5 percent and 15.24 percent across the type of industries. The significant growth rate of labour productivity in all the industries might be due to reduction in working time, high minimum wage which stimulates labourers to work more in less time, keeping less productive persons out of employment and advancement in technology. The co-efficient of determination (R^2) ranged between 0.412 and 0.992 across the industries.
- Across the industries, the growth of partial factor productivity of capital was maximum (3.17 fold) in the manufacture of coke and refined petroleum products and nuclear fuel with the trend rate of 11.2 percent. Whereas the remaining high technology manufacturing sector had shown the growth varying between (1.15 fold) and (1.69 fold). Across the time period it ranged between (1.09 fold) and (1.43 fold) from the beginning of the period to the end of the period. Excepting the manufacture of motor vehicles, trailers and semi-trailers all the industries recorded positive rates.
- The total factor productivity indices were found to be increasing from the beginning of the period in all the high technology industries and during the reference period. But the estimated growth rate of manufacture of basic metals and motor vehicles trailers and semi-trailers were statistically insignificant.
- Employment elasticity with respect to net value added (y_t) in all the high technology industries was positive. On the other hand the elasticity co-efficient in relation to fixed capital (K_t) was positive in 7 out of 10 industries under study. Also it was very clear that the negative elasticities with respect fixed capital in the manufacture of chemical and chemical product, fabricated metal products and transport equipment implied that fixed capital used to be substitute for labour to a larger extent across the industries during the reference period under study.

- The output elasticity with respect to employment (L_t) showed that excepting manufacture of rubber and plastic product and chemical and chemical product, more than a unit increase was brought in all the high technology industries which was considered to be statically significant Output elasticity with respect to fixed capital (K_t) revealed that more than unit change with statistically significance was noted in the manufacture of chemical and chemical product, rubber & plastic products. Inverse relationship could be observed in 3 out of 10 industries. The co-efficient of R^2 in all the high technology industries was high, which explained the fact that the fit was good.
- Wage elasticity with respect to labour productivity (Lp_t) showed mixed trend. Whereas manufacture of chemical and chemical products showed negative relationship with respect to net value added (Y_t) was negative. The co-efficient determination R^2 calculated for all the industries in all the periods explained the fact that the fit was good. The contribution of the independent variables over influencing dependent variable was high. Only negligible percent of change would be brought about by related variables.
- The production function showed that efficiency parameter 'A' or the organisational efficiency was positive in all the industries. Capital co- efficient $\beta1$ was positive in all the high technology industries which implied that there existed positive relationship between output and capital. Wage co-efficient $\beta2$, was also positive and statistically significant for the manufacture of coke, refined petroleum products and nuclear fuel, motor vehicles, trailers and semi-trailers, fabricated metal products, machinery and equipment **n.e.c.**, electric machinery and apparatus n.e.c**.** and transport equipment industry.
- The sum of co-efficients $\beta1$and $\beta2$ shows increasing returns to scale in all the high technology industries. It was also surprising to note that the R^2 was high in all the industries. The percentage share of factor inputs presented indicated that the percentage share of wage was higher, varied between 20 percent and 97 percent. It was maximum for fabricated metal products (97 percent). With regard to type of technology adopted by the industries it could be observed that industries were adopting both labour intensive as well as capital intensive technology since the co-efficient of capital and wage were mixed .

Conclusion

MP_L ratios across major high technology industries in India showed instability in its growth. The variations in MP_K ratios might be due to wage differentials across the high technology industries. Differences in the marginal productivity ratios of labour and capital brought about differences in marginal rate of technical substitution. More than ninety percent of the variation in the growth of labour productivity was due to the influence institutional factors. The varying levels of magnitude of total factor productivity trends explained the fact that across the industries the significant growth rate might be due to the provision of better infrastructural facilities available to these industries. The contribution of entrepreneurship to output was positive.

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APPENDIX-BASIC DATA

TABLE-1

NUMBER OF FACTORIES

Year / Industries	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
CHEMICAL&CHEMICAL PRODUCTS	10577	10395	10226	10747	10995	11065	11177	8456	8418	11202
BASIC METALS	6746	6607	6523	6736	7228	7795	7782	8656	8921	11249
NON-METALLIC MINERAL PRODUCTS	11758	11660	11838	13223	13999	15085	15850	16588	17469	22880
COKE,REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL	885	948	918	990	1037	965	1054	953	1168	1431
MOTOR VEHICLE,TRAILERS AND SEMI-TRAILERS	2736	2902	2757	3093	3069	3261	3310	3662	4186	5139
RUBBER&PLASTIC PRODUCTS	7094	6816	6999	7225	7353	7798	8187	8335	8344	11852
FABRICATED METALPRODUCTS	7999	7916	8051	8138	8534	9019	9872	9773	10854	14844
MACHINERY & EQUIPMENTN.E.C.	8832	8887	8850	9387	9531	9574	9771	8917	9009	11889
ELECTRICAL MACHINERYN.E.C.	4076	3875	3868	3923	4069	4046	4294	5252	5487	7194
TRANSPORT EQUIPMENT	2093	1866	1723	1987	1886	1777	1862	1851	1804	2476

Source: Annual Survey of Industries

TABLE-2

NUMBER OF WORKERS

Industries \ Year	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
CHMICAL&CHEMICAL PRODUCTS	509812	512365	497586	536050	560863	593264	611022	420646	433737	467145
BASIC METALS	400874	400012	400280	431259	488151	590095	628224	696010	697045	767955
NON-METALLIC MINERAL PRODUCTS	373967	504858	361477	422612	471842	546844	552503	637044	648745	739854
COKE, REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL	51495	51841	54990	60048	65471	68990	86273	90161	95202	85307
MOTOR VEHICLE, TRAILERS AND SEMI-TRAILERS	181495	198411	212966	255233	276013	316225	364728	392964	479752	559074
RUBBER & PLASTIC PRODUCTS	201185	197035	210534	228747	243160	264336	275871	331837	375494	400636
FABRICATED METAL PRODUCTS	198398	210135	212832	243741	290063	348327	405564	397186	434767	523221
MACHINERY &EQUIPMENT N.E.C.	265931	268583	263042	298174	316171	362098	390222	407330	385350	462424
ELECTRICAL MACHINERY N.E.C.	181495	157304	150742	168646	199796	215779	245627	277081	331433	376159
TRANSPORT EQUIPMENT	125401	130779	133184	142489	154555	194299	161259	174124	177970	209849

Source: Annual Survey of Industries

TABLE-3

FIXED CAPITAL **(₹.In Lakhs)**

Industries \ Year	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
CHEMICAL&CHEMICAL PRODUCTS	8776266	8020752	8367284	8266390	10794369	11869393	12420262	11695843	11529554	12445679
BASIC METALS	7007091	7660158	8909284	9638083	11974154	13903595	16633692	20917805	33515737	34847595
NON-METALLIC MINERAL PRODUCTS	3496467	3098942	3310239	3727981	3972101	4345670	5922175	7424496	8487583	10924895
COKE,REFINED PETROLEUM PRODUCT AND NUCLEAR FUEL	4723342	5163911	6707310	5531058	6502717	6757162	7201389	7725101	14488621	15396228
MOTOR VEHICLE,TRAILERS AND SEMI-TRAILERS	2197408	1930213	1999582	2448153	2631737	3052750	4574226	6796621	8074427	9779408
RUBBER&PLASTIC PRODUCTS	1487478	1518340	1578068	2016409	1682756	2030023	2345936	3166521	4073123	4708343
FABRICATED METAL PRODUCTS	642739	698981	701966	744681	1023816	1531508	2235220	2570416	2897480	4524488
MACHINERY & EQUIPMENT N.E.C.	1299387	1454535	1429496	1576601	1992620	2169777	2805007	3427979	3920359	5183131
ELECTRICAL MACHINERY N.E.C	952080	1057411	881531	840370	1087643	1258529	1645092	2426943	3172328	4013378
TRANSPORT EQUIPMENT	598176	635237	676647	800789	925677	1166680	1219717	1541894	2009957	2388505

Source: Annual Survey of Industries

TABLE-4

NUMBER OF EMPLOYEES

Industries \ Year	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
CHEMICAL&CHEMICAL PRODUCTS	761244	755113	740441	784907	825435	877083	892944	581053	588667	630017
BASIC METALS	542397	534769	539415	577301	643594	768782	809703	898554	894474	1011699
NON-METALLIC MINERAL PRODUCTS	466848	597717	455373	524429	579170	665007	674904	779786	799669	925250
COKE,REFINED PETROLEUM PRODUCTS	68603	69940	74071	79470	85283	90059	109010	113167	122455	114351
MOTOR VEHICLE, TRAILERS AND SEMI-TRAILERS	251047	267864	285666	336820	359936	408444	466667	509741	619588	715550
RUBBER&PLASTIC PRODUCTS	269292	261691	278654	304476	317414	343001	360285	430981	477507	511842
FABRICATED METAL PRODUCTS	267164	283986	282463	319626	372726	447788	521639	508057	559544	666663
MACHINERY & EQUIPMENT N.E.C.	408898	405244	397945	438048	466239	522911	564085	714174	562167	677982
ELECTRICAL MACHINERY N.E.C.	224301	226654	218091	237190	274467	301676	336010	381336	443771	506628
TRANSPORT EQUIPMENT	167221	171056	174291	185021	199230	241235	205198	219133	222138	260756

Source: Annual Survey of Industries

TABLE-5

NET VALUE ADDED (₹.In Lakhs)

Industries \ Year	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
CHEMICAL&CHEMICAL PRODUCTS	2915352	3311724	3581192	4273582	4859868	5333935	6166290	4592075	5335408	6001476
BASIC METALS	1206591	1900549	2810945	4925070	4257250	6284476	8824217	7186274	7600159	8409009
NON-METALLIC MINERAL PRODUCTS	791902	748176	806738	1191251	1283200	2128285	3163109	3620237	3971847	3431539
COKE,REFIND PETROLEUM PRODUCT PRODUCTS AND NUCLEAR FUEL	751474	1784441	2433067	3020073	4300857	5156007	6551519	7020680	6196196	7773408
MOTOR VEHICLE TRAILERS AND SEMI-TRAILERS,	591883	763870	1200166	1678997	2347565	2287265	2469927	2126779	3403044	3845185
RUBBER&PLASTIC PRODUCTS	544810	578144	637212	699398	711320	779931	1162334	1765860	2121704	2922080
FABRICATED METAL PRODUCTS	395885	423172	504392	603333	910437	1368432	1715972	1776400	2288997	3211307
MACHINERY & EQUIPMENT	966237	899347	1086516	1352361	1773110	2258768	2866653	3892724	4019383	4565055
ELECTRICAL MACHINERY N.E.C.	578306	604913	653823	783993	1247406	1854128	2105803	2378903	2850586	3349589
TRANSPORT EQUIPMENT N.E.C.	466378	541379	633462	790683	957956	1294341	1044063	1275619	1745994	2228415

Source: Annual Survey of Industries

TABLE-6

WAGES TO WORKERS (₹. In Lakhs)

Industries / Year	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
CHEMICAL&CHEMICAL PRODUCTS	322239	317359	320829	349582	377083	424533	471355	361834	399245	497757
BASIC METALS	341771	365685	387048	389510	431804	520400	664480	756728	724177	962412
NON-METALLIC MINERAL PRODUCTS	148534	170381	139486	160694	182152	224151	251964	323833	351375	458968
COKE,REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL	73175	68250	76184	83631	91731	109533	131344	153998	177680	228950
MOTOR VEHICLE TRAILERS AND SEMI-TRAILERS	153836	165778	180979	226318	243682	291578	350711	391755	525687	689736
RUBBER&PLASTIC PRODUCTS	94937	92971	103181	114389	125505	148487	159356	206785	298284	320713
FABRICATED METAL PRODUCTS	98661	107310	109343	126908	153613	195262	253010	294832	340761	499225
MACHINERY & EQUIPMENT N.E.C.	190610	187692	195626	217669	239159	293537	335543	444713	453832	523719
ELECTRICAL MACHINERY N.E.C.	105336	112380	106440	119574	141688	159298	196213	228981	323711	393540
TRANSPORT EQUIPMENT	86038	91356	97269	108157	117616	156863	148846	153734	193986	241779

Source: Annual Survey of Industries

TABLE-7

TOTAL INPUTS (₹.In Lakhs)

Year / Industries	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
CHEMICAL&CHEMICAL PRODUCTS	11669837	12309856	13640568	16062747	18379662	21028679	22829294	23359462	21471089	28015812
BASIC METALS	7835900	9750347	12456679	18746221	20424088	27775977	31758440	40068293	41764304	54628465
NON-METALLIC MINERAL PRODUCTS	238007	2621421	2958341	3635390	3935388	4890030	5914099	8004495	8150578	10371465
COKE,REFINED PETROLEUM PRODUCTS, AND NUCLEAR FUEL	9268455	12565106	14994583	2017635	24673109	31829962	36550224	40443138	46918958	59177157
MOTOR VEHICLE TRAILERS AND SEMI-TRAILERS	3388174	4715681	5536840	12302779	9377111	11402743	13358294	14711627	19209846	25171273
RUBBER&PLASTIC PRODUCTS	2560215	2863646	3324600	4315981	4380618	5638388	6469141	7843220	10107154	12117053
FABRICATED METAL PRODUCTS	1686878	2006313	2452524	3190239	4079233	5696084	7733501	8031521	8318817	11947331
MACHINERY & EQUIPMENT N.E.C.	3403105	3830630	440112	5673191	7471115	8706425	11192658	12784381	12559222	17197141
ELECTRICAL MACHINERY N.E.C.	2305100	2618434	235012	3424259	5411998	7834954	8116724	10501245	12113979	16133795
TRANSPORT EQUIPMENT	2020132	2228158	185066	3510072	3943517	4668175	4425050	5288075	6205485	8514226

Source: Annual Survey of Industries