International Journal of Engineering Research & Management Technology ISSN: 2348-4039

November- 2014 Volume 1, Issue-6

Email: editor@ijermt.org www.ijermt.org

Technological Change in Indian Manufacturing Industry: A Theoretical and Empirical Analysis

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INTRODUCTION

The role of manufacturing sector is crucial for the growth of an economy. This is because the sector tends to have a multiplier effect on other sectors in the economy. The manufacturing sector avails raw materials and services from other sectors in the economy and in turn supplies them with finished products. Hence stimulating demand for everything from raw materials to intermediate goods. Its area of influence includes sectors like software, health, and transportation. World over the manufacturing sector is recognized for creating mass employment for low-skilled workers in the modern sector. With a rapid decline in the capacity of agriculture to offer jobs and the limited scope of the modern services sector to absorb relatively unskilled labor that has been displaced from agriculture, expectations are that the manufacturing sector will create mass employment for this displaced lot. In India also the role of the manufacturing sector is recognized to be critical not only for facilitating large-scale employment but also for enabling high GDP growth.

As a reaction to the colonial past, India's development strategy focused on self-reliance. In pursuit of the same, it placed a heavy emphasis on the creation of a well-diversified industrial base to realize the dream of industry-led development. Though this strategy assigned the prime responsibility of developing heavy industries to the public sector, private sector was also allowed to play a supplemental role. Almost until the beginning of the eighties, a myriad of measures to control the private sector, such as, licensing requirement for installation of capacities, quantitative and tariff restrictions on imported inputs, regulation of monopolies and trade practices, foreign exchange regulation, nationalization of commercial banks, price controls, etc., constituted an integral part of India's industrial policy. The socialistic fervor in the minds of policy makers got reflected in the policy measure, such as, reservation of labour-intensive manufacturing products for the small scale industries (SSIs), preferential treatment to the SSIs, stringent labour laws against firing of labor in large firms, etc. The industrial policy was primarily designed to protect the 'infant' industries from external competition. Unfortunately, it inhibited internal competition as well. By the end of seventies, Indian manufacturing suffered from high costs of production, sub-standard quality of products and lack of competitiveness of its exports. It is no surprise that the regulatory framework of the pre-1980s, inter alia, has been held responsible for low growth rate of output and productivity of India's manufacturing sector.

Nobody would be disassociated with the fact that productivity growth is the only plausible route to an increase in the standard of living. Productivity increases have also been recognized to contribute to economic growth. It is also recognized that economic growth without productivity increase does little for raising the standard of living. Productivity growth lowers labour costs and production, etc. on the other hand, a firm is said to be technically efficient if it is producing maximum output from the given bundle of inputs, maintenance of higher level of

technical efficiency requires not only the adoption of best practice technology, but also the use of that technology to produce maximum output from the given bundle of inputs.

It was only in the 1950s that technological advancement as an important source of growth was brought into the discussion of mainstream economic theory. Solow's (1957) Pioneering attempt to estimate the contribution of physical factors to growth, by introducing the technique of growth accounting, revealed that only 1/8th of the growth of the U.S. economy during the first half of the present century could be explained by the growth of its endowments of physical factors, leaving the remaining to a "residual" [termed as technical progress or Total Factor Productivity growth (TFPG)]. Focus shifted thereafter from physical factors to the role of technology in production and growth.

The study focuses on productivity and efficiency of 'manufacturing sector' for the following reasons. First, during the process of transition (i.e., when growth of an economy is being driven by manufacturing and tertiary sectors rather than by the primary sector), manufacturing sector is known to generate employment for both unskilled and skilled labour and the employment potential of manufacturing sector is higher as compared to that of the tertiary sector. Second, the growth of manufacturing sector is also necessary for the overall growth of the economy, as it can supply inputs and provide market to other sectors. Lastly, we also view that the solution to the agrarian crisis will also be found in the growth of output and employment of manufacturing sector.

REVIEW OF LITERATURE

The economic growth of every nation is inextricably linked to the successful international transfer of knowledge. Substantial resources are required to make a new process or product feasible (Mansfield, 1968). This resource requirement enhances the role of technology transfer in the economic growth of developing countries who are generally financially starved and scarce in human capital (the two basic inputs required for the inventive process). Developing countries need not reinvent-the-wheel but adopt the technology as most of the technologies are available off-the-shelf. The adoption of technology also involves substantial costs to the recipient (Tuma, 1987). This high cost of the technology adoption is because of the tacitness or disembodied form of the technology. Literature on FDI and trade has mainly concentrated on export-substituting or export-complementary nature of foreign direct investment (FDI). However, the relationship between FDI and trade has become far more complex in the current WTO regime wherein several developing countries have initiated import liberalization and entered into trading arrangements. These policy have drastically reduced trading costs, encouraged trade and improves productivity. With the growing volumes of trade, the focus of policy makers in the developing countries has now shifted from whether FDI causes trade or whether trade can boost FDI inflows and in particular, what kinds of trade can boost FDI inflows or productivity enhancement. This research adds to the existing literature by investigating the impact of liberalization policies associated with cross-border vertical integration and intra-industry trade on FDI flows for the Indian Manufacturing industry in the pre and post reforms period.

Further we have reviewed the studies as per our study used the measures for liberalization and technological change in manufacturing industry.

The study done by Dijkstra aims to what extent trade liberalization affects an economy like Latin America. He assess what happened to domestic prices for importable and exportable, if the exchange rate is overvalued, or if there is an oligopolistic market for exportable and importable. It also take into account the comparisons of labour and capital productivity before and after the trade liberalization. He leads to the conclusion that the short term positive effects are hampered if there is oligopolistic competition in the domestic market, be it in production or in trade. The net improvements on the efficiency of manufacturing industry depend on the relative importance of import competing, exporting and imported-inputs-intensive branches of manufacturing. If domestic markets allow for changes in relative prices to occur and if other supportive factors are available, allocative efficiency will generally improve from trade liberalization. Short term effects are larger for small countries than for large

countries. However, the potential adjustment costs are also larger, so welfare may decrease in the short run. Long run effects will occur in countries that already have a firm industrial base as that are far ahead in the process of getting it, countries which have low industrial base are expected to miss out on these long run effects.
The estimates of Goldar and Anita Kumari on total factor productivity growth were presented for Indian Manufacturing and major industry groups for the period 1981-82 to 1997-98, i.e.; the post reform period, with that in the 1980s. This was followed by an econometric analysis of inter-temporal and inters industry variations in productivity growth rate, aimed at assessing the effect of import liberalization on productivity growth in Indian industries in the 1990s. Another aspect was the effect of capacity utilization on measured productivity growth. The result showed that total factor productivity growth in Indian manufacturing decelerated in the 1990s econometric analysis presented in the paper indicated that the lowering of effective protection to industries favorably affected productivity growth. The result suggests that gestation lags in investment projects and slower agricultural growth in the 1990s had an adverse effect on productivity growth. The analysis revealed that underutilization of industrial capacity was an important cause of the productivity slowdown. With corrections for capacity utilization, the estimated productivity growth in the 1990s was found to be about the same as in the 1980s.

The study of Chow investigates the causal relationship between export growth and industrial development in eight Newly Industrializing Countries (NICs). Results of small causality test showed that for most of the NICs there was strong bidirectional causality between the growth of exports and industrial development. These findings support the export growth strategy, expansion in exports not only promote the growth of national income but also lead to structural transformation of the developing countries.

The study of Feder analyzed the sources of growth in the period 1964-73 for a group of semi-industrialized less developed countries. An analytical framework was developed, incorporating the possibility that marginal factor productivities were not equal in the export and non-export sectors of the economy. Econometric analysis utilizing this framework indicates that marginal factor productivities are significantly higher in the export sector. The difference seems to drive, in part, from inter sect oral beneficial externalities generated by the export sector. The conclusion was that, the growth can be generated not only by increases in the aggregate levels of labor and capital, but also by the reallocation of existing resources from the less efficient non-export sector to the higher productivity export sector.
The study done by Laiz R. De Mello Jr examined the impact of Foreign Direct Investment (FDI) on capital accumulation, output and Total Factor Productivity (TFP) growth in the recipient economy. Time series and panel data evidence are provided for a sample of OECD and non-OECD countries in the period 1979-90. Although FDI was expected to boost long run growth in the recipient economy via technological upgrading and knowledge spillovers, it was shown that the extent to which FDI growth enhancing depends on the degree of complementarily and substitution between FDI and domestic investment.

Goldar and Veeramani investigate the various dimensions of Investment Climate (IC) in determining Total Factor Productivity (TFP) in the manufacturing sector across the major Indian States. The study assumes that India's overall economic progress during the reform period has been leaving some of the states behind. They undertake a regression analysis to investigate the effect of IC on TFP. They found that a market friendly investment climate was important for achieving higher levels of productivity. A market friendly investment climate, however, does not mean that the regulatory function of the government should be done away with, government regulation was crucial to address market failures and to protect social interests, but the policies and practices of the government should be transparent and designed without distorting the incentives of the firms to invest and grow.
Jenn-Hwan Wang analyzed the divergent models pursued by South Korea and Taiwan in regard to technological catching-up and their ongoing transition towards innovation-based economies. It was found that South Korea's

former high-debt and chaebol-dominated model inclined it to pursue a Schumpeterian scale based technological development, while Taiwan's former pro-stability, Small and Medium-sized-Enterprise (SME) based model tended to favor its emphasis on a Neo-Marshallian network-based technological development. It was argued that the state's approach to economic liberalization and firms demand for capital and technological upgrading are the major factors which underpinned the adjustment efforts of these two countries.

Chakraborty examined the time series properties of foreign capital inflows into India in the 1990s, particularly in the period that followed certain liberalization measures in the financial sector. The analysis of quarterly data for the period 1993 to 2003 showed that net capital inflow have been volatile though not all components of aggregate inflows have moved in a similar fashion. It further analyses how capital inflows adjusted to changes in the real exchange rate and other macroeconomic variables in India since 1993. The econometric results indicated that an error-correction mechanism was operating between net inflows of capital and the real exchange rate. Macroeconomic fundamentals did not have any significant effect on the dynamic adjustment of capital inflows, and a co-integration relationship exists between the net inflows of capital, real exchange rate and interest rate differential. It was argued that co-movement in these variables was due to the intervention of Reserve Bank of India in the foreign exchange market, which helped in preventing the volatility of the real exchange rate inspite of the volatility in net inflows of capital.

Puran and Jayant surveyed the available literature on productivity growth and technical change in six energy intensive industries in India covering the period 1947-1998. It assesses the magnitude of the Autonomous Energy Efficiency Improvements (AEEI) parameter for India's industrial sector. The survey revealed productivity growth to be an active area of research in India, both at the aggregate level as well as the industry level. It indicates wide inter-and intra-industry variation in estimates of partial and total factor productivity due to differences in methodology, levels of aggregation, sources of data, time periods of analysis, and reporting procedures. The overall impression was positive imperceptible growth in productivity overtime. The policy implication was that little reliance can be placed on the AEEI factor as the moderating influence on growth of energy demand.
Joseph and Abraham investigated how India faced in terms of harnessing Information technology for enhancing manufacturing productivity. They analyzed an unpublished data set on the investment in computers and software at the industry level made available by CSO. The study finds that IT investment does have a positive and significant impact on both partial and total factor productivity. Findings of the paper suggests policy measures and an institutional intervention towards promoting IT diffusion in the manufacturing sector, and is likely to give rich dividends.

Berhanu Abegaz used cross-country panel data on three digit manufacturing to test for progressive structural convergence in industrial output mix between industrializing and industrialized economies. Regression based on logistic and almost ideal models show that industrial deepening entails share losses for light and selected heavy manufacturing, and share going for engineering and consumer durables. While semi-industrial economies manage to shift into petrochemical and engineering industries, the least industrialized nurture a broad spectrum of non-traditional manufacturing. Diversity in factor endowments and policy notwithstanding, growing similarity in demand and technological diffusion appear to produce weak convergence of industrial structures between developing and developed countries.

The study carried by Neelam Singh examined the firm level determinants of R&D, import of technology and (merchandise) trade intensities along with their interdependence for a sample of primarily pharmaceutical manufacturing companies operating in India. Export orientation, import substitution and in-house technological effort are closely linked to the development of an industry, subsuming the technological development. They took

sample of 35 large and medium-sized private sector pharmaceutical companies operating in India covering the period 1988-89 to 1991-92. They found strong interdependencies among the exogenous variables of the model. R&D and technology import intensities strengthen each other. While capturing the simultaneity, the simulative (consistently positive) effect of import of technology on R&D intensity holds, indicating a complementarily high R&D intensity and boosts the export sales ratio, somewhat more for local firms considering the large favorable effect of export intensity on R&D intensity.

Asplund and Sandin investigated about the positive correlation between market size, number of firms and competition was more intense in larger markets. They test these on a sample of 250 Swedish regional markets by estimating the relation between the number of firms, production capacity, and market size. The number of firms increases less than proportionally with market size. Market size per capacity unit 1% smaller in large markets. Since firms produce fairly homogenous goods; they argue that this is evident that profits per capita are decreasing in market size.

The study done by M. Parameswaran examined two important components of the total factor productivity growth, namely technical change and technical efficiency change of firms belonging to the capital goods producing industries. Empirical analysis of these two components was motivated by the policy changes that capital goods producing industries were subjected to during the 1990s as well as by the existing evidences on the total factor productivity growth in Indian manufacturing industry. Technical change and technical efficiency change were estimated in a single step, using a Stochastic Frontier production function. The result of the study showed that all the industries studied experienced a significant improvement in the rate of technological progress during the post-reform period. However, the evidence on technical efficiency showed that not only the level of technical efficiency was lower during the post reform period, but also the rate of decline in the technical efficiency was higher in all industries except in one. Thus the paper provides further insight into the productivity performance of these industries during the post reform period.

The study of Chappelle and Plane analysed the productive performance in four manufacturing sectors of the Ivorian economy: textiles and garments, metal products, food processing, wood and furniture. To appraise the productive performance, econometric production frontier models were used, illustrating the maximum output attainable from a given quantity of inputs. The frontier and firm efficiency scores are derived from stochastic production functions estimated on cross-sectional data. The stochastic specification of the models allows for the decomposition of the error term into two components, one the normal random effect and the other to account for technical inefficiency. It was explained by various exogenous variables describing the economic and institutional environment. Firm size proves to be a statistically significant determinant of the productive performance. Across the four sectors, the positive impact of being large compensates the negative effect of a formal institutional status in an environment where government regulations still prevail.

OBJECTIVES OF THE STUDY:

The present study has the following objectives-

1. To compare the industrial performance of India before and after liberalization.
2. To examine the impact of liberalization on technological change in Indian manufacturing sector i.e. to examine whether import liberalization, foreign direct investment and export orientation had improved productivity in the Indian manufacturing sector.

RESEARCH METHODOLOGY

The motivation for this study was derived from the fact that India has a large surplus labour available and agriculture alone cannot boost the development, so productivity increase in manufacturing sector is the root

through which inclusive growth would be achieved. Unlike many other countries, India has not witnessed a stylized sectoral growth process during her developmental process. India's service sector led growth in the recent years has been viewed with some apprehension in terms of fostering inequalities across regions and sections of population. Concerns have also been raised about the widening regional and sectoral dispersion of growth and jobless growth in the context of economic reform process that gathered momentum in the early nineties.

Total Factor Productivity Growth has been calculated for measuring the performance of Indian Manufacturing industries. To calculate the Malmquist Productivity Index (MPI) in Indian manufacturing industry, DEA method has been used. The use of MPI has been preferred over traditional non-frontier techniques given the property of MPI that it decomposes the Total Factor Productivity change into two mutually exclusive and non-additive components namely, Efficiency Change (indicator of catching-up) and Technological Change (indicator of shift in production function).

To see the relationship between liberalization and productivity in Indian manufacturing industries multiple regression was applied. We use import intensity, export intensity, real effective exchange rate and foreign direct investment as an indicators of liberalization. We have taken data for this study from Annual survey of industry, Reserve bank of India and different issue of economic survey.

To analyze the impact of economic reforms on Total Factor Productivity growth of Indian manufacturing sector the entire study period has been bifurcated into three sub periods namely pre-reforms period(1980-81 to 1990-91) and post-reform period (1991-92 to 2000-01, and 2001-02 to 2009-10).

The main findings of the study are summarized below:

- Positive Total Factor Productivity change in the period-I was explained in terms of positive Technical Change as compared to Efficiency change which was either negative or very low. The average Efficiency Change was 0.977. This showed a efficiency regress at the rate of over 2 percent per year. On the other hand the average Technical Change and Total Factor Productivity Change registered noticeable 9.3 percent and 6.7 percent change per year. This indicated that Total Factor Productivity change in this phase was explained by Technical Change Factors.

- In period-II most of the reform measures were introduced due to which we found Total Factor Productivity change in most of the years was positive and this change was also very large in some of the years. The reason for positive Total Factor Productivity change was remarkable increase in Technical Change observed in most of the years, although Efficiency change was negative in the same period. The average Efficiency Change was 0.977. This showed a efficiency regress at the rate of over 2 percent per year. However average Technical Change and Total Factor Productivity change registered 6.9 percent and 4.5 percent change per year. This indicated that improvement in Total Factor Productivity change in this phase was explained by Technical change factors.

- In period-III Total Factor Productivity change was positive for most of the years except in 2002 and 2007 in which we observed a regress in Total Factor Productivity change, due to a regress in Technical Change. In 2006 highest Total Factor Productivity growth of 76.2 per cent has been observed. The positive change in Total Factor Productivity was explained in terms of both Technical Change and Efficiency change, in some years contribution of Technical Change was greater in Total Factor Productivity as compared to Efficiency change. The average Efficiency was 1.009. This showed marginal improvement in Efficiency Change per year. On the other hand average Technical Change and Total Factor Productivity Change registered 6.6 percent and 7.6 percent increase in Technical Change and Total Factor Productivity Change per year. This indicates that the growth in productivity in this phase was explained by Technical Change Factors.

- In most of the years of study i.e, 1980-81to 2009-10 Total Factor Productivity change was positive except in some cases regress in Total Factor Productivity change has been observed. In overall study period this positive Total Factor Productivity change was explained more by Technical Change as compared to Efficiency change. If we compare the Total Factor Productivity change of Manufacturing sector in pre-reform and post reform period, Total Factor Productivity change was positive in most of the pre-reform years, but Total Factor Productivity change was negative for three years in the same period. The contribution of Technical Change in Total Factor Productivity change was greater as compared to Efficiency change in the pre-reform phase which was started from 1980-81. In post-reform period which was started from 1991-92 Total Factor Productivity change was positive, this positive change was explained both in terms of Technical change and Efficiency change, but the contribution of Efficiency change was greater as compared to Technical change. The average Efficiency change in overall study period registered 2 percent increase per year. While the average Technical Change was 1.023, it showed 2.3 percent improvement in Technical Change per year. Average Total Factor Productivity change was 1.025. This indicated improvement of 2.5 percent in Total Factor Productivity change per year. This indicated that growth in this phase was due to Technical change factors.

Findings on performance and determinants of Total Factor Productivity change in Indian Manufacturing Industry Subgroups:

- In period-I all manufacturing industries experienced positive Total Factor Productivity change. The industries having highest Total Factor Productivity change were wood, wood product and non-metallic industry; they registered 12.7 per cent and 10.7 per cent Total Factor Productivity growth respectively. The lowest Total Factor Productivity growth of 4.2 per cent has been experienced by machinery, machine tools industries due to a regress in Efficiency change. The positive Total Factor Productivity change in majority of the industries was explained in terms of remarkable increase in Technical change as compared to Efficiency change which was negative for all except in case of non-metallic industry.

- In period-II we found positive Total Factor Productivity change for all industries except for food product industry which registered a regress in Total Factor Productivity change. Non metallic industry with 9.3 per cent Total Factor Productivity growth was the highest performer in this period. The positive Total Factor Productivity change in most of the industries in this phase was explained by the majority contribution of Technical change as compared to Efficiency change which was negative for all industries except in case of cotton textiles and rubber industries.

- In period-III Total Factor Productivity change registered positive growth in all manufacturing industry subgroups except in cotton textile industry which experienced a regress in Total Factor Productivity change. Other manufacturing and machinery and machine tools industry registered highest Total Factor Productivity growth of 19.6 per cent and 10.6 per cent respectively. The positive Total Factor Productivity change in majority of industries was explained in terms of Technical change as compared to Efficiency change. Contribution of Efficiency change in Total Factor Productivity change was low as compared to Technical change.

In sum, in comparison of productivity growth during three sub periods it was revealed that Total Factor Productivity growth in Indian manufacturing sector has fallen from 6.7 percent per annum during pre reform period to 4.7 percent per annum during the first phase of post-reform period, Total Factor Productivity growth registered 7.6 per cent increase per annum only in the second phase of post reform period which was marginally

better than the pre-reform growth of Total Factor Productivity growth. Hence at aggregated levels impact of economic reforms was not in a desired direction as envisaged by the policy planners of India.

In the manufacturing industry subgroup out of 12 Manufacturing Industries six industries were showing positive Total factor productivity change and another six industries were showing a regress in Total Factor Productivity change throughout the study period i.e,1980-81 to 2009-10.The lowest performers were food product and cotton textile industry, this low performance can be explained in terms of Technical change, since this was negative throughout the period, Efficiency change was positive but this positive change was waved off by negative change in Technical change and it resulted into negative Total Factor Productivity change. The highest performers were other manufacturing and transport equipment industry, these industries registered 14 per cent and 12.8 per cent average Total Factor Productivity change respectively. If we compare the manufacturing industries having positive Total Factor Productivity change and those who were having negative Total Factor Productivity change, we found in low performers with negative Total Factor Productivity change the reason was a regress in Technical change because Efficiency change was positive in most of the industries. Manufacturing industries having positive Total Factor Productivity change showed both Efficiency change and Technical change was positive, but the higher proportion of Total Factor Productivity change was explained by Technical change as compared to Efficiency change.

Findings of Multiple Regression Analyses:

- The panel data regression analysis showed that out of four explanatory variables import intensity was the only variable which positively affects the Total Factor Productivity and Technical change in Indian manufacturing industry in the study period. Except import intensity no other variable affect determinants of productivity positively, but their negative effect was also not significant.
- In period- I import intensity was the only variable which positively contributes in Total Factor Productivity and Technical change in Indian manufacturing industry, but its contribution was not significant. Other explanatory variables effect determinants of productivity negatively, but were not found statistically significant.
- In period- II import intensity and real effective exchange rate (REER) positively contribute in the productivity of Indian manufacturing industry. The contribution of REER was also significant as compared to other variables.
- In period- III import intensity, foreign direct investment (FDI) and REER positively effect the productivity in Indian manufacturing industry. However the contribution of REER was found significant in this period. Contributions of other explanatory variables in determinants of productivity of manufacturing industry were not found significant.

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