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Econometric Analysis of Industrial Performance in Electronic Industry of India

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Abstract*:* The article attempts to evaluate productivity performance of Indian electronics industry in terms of total factor productivity growth for the entire period, 1979-'80 to 2008-'09. The result on the overall productivity shows declining total factor productivity growth during post-reform period as compared to pre-reform period. The liberalization process is noticed to have its adverse impact on total factor productivity growth. The negative and significant impact of liberalization on productivity suggests that trade policy should focus on productivity enhancing industrial policies that will, in turn, help firm to enter export market after gaining real competitive edge.

Key words: Electronics, Productivity, Liberalization, Industry, Capacity utilization.

JEL Classification: D24, L63.

1. Introduction

The policy reforms initiated since 1991 in India had the objectives to make Indian industries as well as entire economy more efficient, technologically up-to-date and competitive. This was done with the expectation that efficiency improvement, technological up-gradation and competitiveness would ensure Indian industry to achieve rapid growth. In view of greater openness of Indian economy due to trade liberalization, private sector can build and expand capacity without any regulation. The proponent of liberalization believe that this policy reforms will improve industrial growth and performance significantly while critics argue that total withdrawal of restrictions on several matters will have a negative effect on future growth and performance of the industry.

Growth of a firm depends on the efficient and rational use of the scarce resources, both labor and capital, available to the firm. In other words, it is the level of productivity of the factors of production that determines the rate and sustainability of the firm. However, a large percentage of growth in output remained unexplained after accounting for input (labor and capital) growth. The concept of total factor productivity (TFP) gained importance and appeal when it was recognized that output growth could not be fuelled by continuous input growth in the long run due to the nature of diminishing returns for input use. For sustained output growth, TFP growth is essential and therefore, TFP growth became synonymous with long-term growth as it reflects the potential for growth (Mahadevan, 2004).Actually, the performance of an industry can be assessed with the help of various targets, past achievements and financial yardsticks or in terms of productivity performances. In a capital scare economy like India, manufacturing productivity is such a key indicator of economic performance. Theoretically, TFP is a relevant measure for technological change by measuring the real growth in production value, which cannot be explained by changes in the input of labour, capital and intermediate input.

1.1. Profile of Indian Electronic Industry

Electronics and IT Hardware Industry is the largest and fastest growing manufacturing Industry in the world. Despite current recession , the Indian IT hardware &Electronics Industry has grown at approximately 7% per annum compared to global GDP growth of 3-3.5%. The electronic industry in India constitutes just less than 1% of the global electronic industry. However, the demand in the Indian market is growing rapidly though it remains a major importer of electronic materials, components and finished equipment. A series of market studies during the last few years have forecast rapid growth of electronics hardware demand in India, going up from the existing US$40 billion to US$155billion by 2015 growing at 20%+ annual growth rate. This would be 12% of the projected GDP in 2015 against the present 2%. A manufacturing output of US$ 155 billion would have the potential to create employment of 21 million (7million direct + 14million indirect) and Revenue of approximately US$ 56 Billion (Rs.274,000Crores) including direct and indirect taxes (State and Central). Present total employment in the sector is less than 2.5 Million and Revenue is less than Rs.25, 000 Crores.During the last 10-15 years, countries such as China, Korea, Taiwan, Singapore and Malaysia have emerged as leading global IT hardware and electronics manufacturer/exporters and has contributed significantly to the growth of their economies. Indian electronics Industry has failed to keep pace with these countries and it is still in a nascent stage of development, though the country's software industry is well developed and highly competitive in the global market.

The Indian electronics industry has been broadly classified into two categories, namely IT Hardware &

Electronics and Software. The production of IT (Hardware and Software) and electronics, which was worth about Rs 150 million in 1960, has increased to Rs 1730 million in 1971 and Rs 8900 million in 1981. It has further increased to Rs 94,344 million in 1991 and to Rs 35,01,300 million in 2008.During the period 1991-2008, the electronics industry as a whole experienced an overall annual growth of 23.69 per cent**.** However, major growth can be traced to Indian software and services industry that grew at the annual rate of 40.63%, in comparison, the IT hardware and electronics sector experienced a moderate growth of only 14.34% during the same period. By 2008, the production of software and services in India reached Rs. 25,80,000 crore. The Business Process Outsourcing (ITES-BPO) sector has emerged as a key driver of this phenomenal growth in the Indian software and services Sector.It is of course, encouraging to note that in recent decade (2001-2008) IT hardware and electronics sector has experienced a higher growth than the last decade (1991-2000).But production of electronics and IT hardware as a proportion of total production in the electronics industry has been continuously declining as it declined from 45 percent in 2000 to 26 percent in 2008.

Table 1: Ranking and share (%) in Electronics Production

Country	**Electronics**					
	Ranking			**share (%)**		
	1998	**2001**	**2004**	**1998**	**2001**	**2004**
China	3	3	3	4.8	8.3	14.7
France	8	11	11	3.4	2.7	2.4
Germany	4	5	5	4.6	4.3	3.9
India	**28**	**29**	**24**	**0.4**	**0.4**	**0.5**
Japan	2	2	2	18.1	16.7	14.9
Malaysia	10	7	6	2.7	3.5	3.6
S. Korea	6	4	4	3.8	4.7	5.8
Singapore	7	9	8	3.5	3.1	3.2
Taiwan	9	8	7	3.1	3.4	3.6
UK	5	6	9	4.4	4	3.2
USA	1	1	1	29.8	28.2	25.1

Source: Kumar (2006), Electronics Information and Planning, Vol 33, 3 –4, Dec2005-Jan-2006.

USA leads in equipment manufacturing whereas Japan is leader in component manufacturing. Moreover, the production base of electronics hardware is gradually shifting to countries like China and S. Korea. After USA and Japan, it is China that has emerged as 3rd largest electronic hardware production center and its share has grown from 8.3 per cent in 2001 to 14.7 percent in 2004. The ranking of India along with the top 10 electronic hardware and electronic components producing countries is shown in Table 1. These top 10 countries together contribute nearly 80 per cent world electronics production and 85 per cent of world electronic and components production respectively. Japan and USA together contributed 48.6 per cent of electronic component production in 1998, which decreased to 43.4 per cent during 2004 where as that of China improved from 4.1 per cent in 1998 to 10.1 per cent during 2004.

The Indian IT Hardware and Electronics market is segmented product wise into seven broad categories namely, Consumer Electronics, Controls, Instrumentation & Industrial Electronics, Electronic Data Processing (IT Hardware), Communication & Broadcast Equipment, Strategic Electronics and Electronic Components.The overall production scenario in the Indian Electronics and IT Hardware sector is far behind its current market demand of US$40 billion. The estimated production of various segments of the industry during 2007-08 was estimated at US $ 20 billion.In recent times, some SMEs are making investment in the tax-exempted regions and are mostly doing Original Equipment Manufacturers (OEM) work for reputed Brands.The electronics industry in India had initially grown around three major centers, Bangalore, Mumbai/Pune and Delhi. Bangalore not only has major public sector units in defence and telecommunication but also has a very fast-growing, organised private sector firms in computer and industrial products. Bombay /Pune has been always a preferred destination for private sector firms and MNCs. However, eastern India remained underdeveloped in electronics and IT hardware production. The secondary electronics centers include Hyderabad, Hosur, Thiruvananthapuram, Chennai, Kolkata, Vadodora, Mohali, Ahmedabad and Aurangabad.Uttar Pradesh has emerged as the leading state in the production of electronics and IT hardware since 2001. Delhi also occupies a significant place due to large concentration of small scale units making consumer electronic products and computers.

We focus on electronic industry for several reasons. Firstly, it is a sector which is expanding rapidly and whose effects are permeating the production structures of virtually every activity in manufacturing and service sectors.Secondly, it is a sector which has a high level of globalization potential.Its production is effectively footloose,being virtually independent of resources other than capital,for which there is now a global market and labour both skilled and unskilled.Thirdly, because of weightlessness of many of the products of the sector, transportation costs which can often play a vital role in linking production to consumption, are a trivial part of total cost.For these reasons, differences in factor costs,effectively the cost of skilled and unskilled labour ,can drive the global production location decisions for different fragments in the production process.

In view of the above discussion, the article tries to evaluate the industrial performance of Indian electronic industry in terms of total factor productivity growth for the period,1979-80 to 2008-09 dividing the entire period in to pre and post reform period .

The structure of the paper is follows: literature regarding TFP Growth has been reviewed briefly in section 2, section 3 discusses the methodological issues, section 4 presents the results and section 5 depicts summary and conclusions.

2. Brief overview of literature

Empirical studies suggest that trade reforms promoted total factor productivity (TFP) in Indian manufacturing during eighties' (Goldar1986, Ahluwalia1991, and Chand and Sen2002). There is adequate reason to suppose that manufacturing sector responds to liberalization and the high growth rate during nineties' was 'due to continued structural reforms including trade liberalization, leading to efficiency gains'.(WTO,2001,p1). This view has been supported by Krishna and Mitra (1998) and Unel (2003) who found that growth of TFP was higher in nineties' compared to the period upto 1990-'91. Das (2003) reported that a positive impact of lowering of NTBs on manufacturing as well as intermediate goods sector promoted industrial productivity. Turning to the trends in productivity in the post-reform period, the evidence from empirical studies by researchers was ambiguous, though subjective evidence, especially of trends of recent years shows significant increases in productivity growth. Tata Service Ltd (TSL), 2003) has reported a faster growth rate in TFP in Indian manufacturing in post-reform period as compared to pre-reform period. Despite ambiguity regarding acceleration in TFPG, evidence suggests that trade liberalization since 1991 had a positive impact on the TFPG in India (Krishna and Mitra, 1998; Chand and Sen, 2002; Das, 2003; Topalova, 2004). At the sectoral level, there is evidence of improved TFPG in exporting sectors vis-à-vis the non-exporting ones (Dholakia and Kapur, 2001; Unel, 2003) Kathuria (2002) finds that productivity of foreign owned firms improved in the post-reform period and Indian owned firms which invested in R& D gained from productivity growth. Kato (2005) finds that smaller the market share of a firm, higher is the productivity growth.

Goldar and Kumari (2003) report a declining trend of TFP growth in Indian manufacturing in 90s resulting that gestation lag in investment projects and slower agricultural growth in the 90s had an adverse impact on productivity growth. Several studies(Das,1999,2003, Singh et.al 2000,Kumari,2001,Srivastav,.2001) find TFP growth in Indian manufacturing deteriorated during nineties compared with that of eighties'.Balakrishnan et.al (2000) reports a significant decline in the growth rate of TFP since 1991-'92 in five manufacturing industries in India and they failed to find a link between trade reform and TFP growth in the nineties'.Rajan.S.S el.al(2008) find declining TFPG in Indian iron and steel industry probably due to inefficient utilization of factors of production particularly underutilization of labour input in accordance with changing demand, together with sluggish growth in technical progress. Most of the studies on productivity in India have focused on the growth in TFP in Indian manufacturing . These studies suggest a decline in total factor productivity growth till 1970s,with a turn around taking place in mid 80s',pursuant to the reoriented trade and industrial policies and improved infrastructure performance(Brahmananda,1982;Ahluwalia,1991;Balakrishnan and Pushpangadan 1994;Majumder,1996, Rao,1996, Pradhan and Barik,1999) . The proposition that the TFPG accelerated during the 80s' would be consistent with the recent debatable view associated with Rodrik and Subramanian(2004) who argued that transition to high growth phase occurred around 1980- a full decade before economic liberalization-that started being adopted during the 1980s. Given this ambiguity, the effect of trade reforms on total factor productivity growth is an empirical issue.

After reviewing the literature, it can be observed that most of the studies conducted so far are on aggregate manufacturing, the coverage of which is not till 2008-09. The present study is a wide-ranging analysis on Indian electronic sector in terms of total factor productivity growth for the period,1979-80 to 2008-09.

3. Methodology

3.1. Description of data and measurement of variables

The present study is based on industry-level time series data taken from several issues of Annual Survey of Industries, National Accounts Statistics, *CMIE* and economic survey, statistical abstracts (several issues), Year book of World Electronics data,2008-09, *RBI* bulletin on currency and finance, handbook of statistics on Indian economy, whole sale price in India prepared by the Index no of office of Economic Advisor, Ministry of Industry etc covering a period of 30 years commencing from 1979-80 to 2008-09. Selection of time period is largely guided by availability of data.[1]

In order to avoid over estimation due to ignoring contribution of material input on TFP, a third variable of intermediate inputs (material including energy input) [2] has been incorporated in the value-added function as such to obtain gross output. Pradhan and Barik (1999) argued that the gross output, instead of value added, appears to be the appropriate choice of TFPG estimation in India. Generally, TFP growth estimates based on value added terms are over estimated since they ignore the

[1] Till 1988 – 89, the classification of industries followed in ASI was based on the National Industrial classification 1970 (NIC 1970). The switch to the NIC-1987 from 1989-90 and also switch to NIC1998 requires some matching. Considering NIC1987 as base and further NIC 1998 as base, Electronic industry has been merged accordingly. For price correction of variable, wholesale price indices taken from official publication of CMIE have been used to construct deflators.

[2] Earlier studies that have not treated material including energy as separate factor of production, has failed to pick-up significant economies that are likely to generate in the use of such input. Jorgenson (1988) has observed that in a three input production framework, the contribution of intermediate inputs like material, energy etc. are significant sources of output growth.

contribution of intermediate inputs on productivity growth (Sharma, 1999). Therefore, modified gross value of output so calculated has been used as a measure of output suitably deflated by wholesale price index of manufactured. Deflated cost of fuel (Appendix-A-1) has been taken as measure of energy inputs. Deflated gross fixed capital stock at 1981-82 prices is taken as the measure of capital input. The estimates are based on perpetual inventory method. (Appendix-A-2) .Following the same line as adopted in deflating energy input, the reported series on materials has been deflated to obtain material inputs at constant prices.Total number of persons engaged in Indian electronic sector is used as a measure of labor inputs as is reported in ASI which includes production workers and non-production workers like administrative, technical and clerical staff (Goldar et.al. 2004). For recent issues, it is reported in ASI under the head 'persons engaged', for earlier issues, it is reported as 'number of employees'.

This paper covers a period of 30 years from 1979 -80 to 2008-09.The entire period is sub-divided into two phases as pre-reform period (1979 -80 to 1991-92) and post-reform period (1991-92 to 2008-09), sub-division of period being taken logically as such to assess conveniently the impact of liberalization on TFPG .

3.2. Concept of Productivity

Productivity is a marginal contribution of a factor to the output growth of a product. It is defined as the ratio of the output of a commodity measured in real terms to that of one or more of the input used, also measured in real terms. This definition is very crude but captures the essential concept. Total factor productivity (TFP) shows the relationship between a composite input and the output, calculated as a ratio of output to input. Productivity increases when the growth in output is greater than the growth in input, or when the rate of growth of output minus the rate of growth of composite input is positive. Economic growth can be obtained either by increasing inputs or by improving productivity factor. Productivity growth occurs when a higher output can be attained with a given amount of input, or a certain level of output can be attained with smaller amount of factor input. This productivity growth is obviously preferable to growth due to increases in factor inputs, since the latter might be subject to diminishing marginal returns.

Empirical studies show that growth in output cannot be totally explained simply by the growth in the aggregate factors of production. The residual growth of output that cannot be explained by the growth of the inputs is caused by a host of influences that are difficult to categorize precisely. Denison (1967) calls it the 'measure of our ignorance' This 'residual factor' is supposed to cause the growth in total factor productivity (TFPG). TFPG is loosely referred to as a measure of technical change.

Technical progress and total factor productivity are often used synonymously, though there is a conceptual distinction between them. Technological progress is advances in knowledge and its application to the art of production (invention, innovation and diffusion).It may take the form of new goods, new processes or new modes of organization. On the other hand, total factor productivity (TFP), defined as the ratio of output to a weighted combination of inputs, and may have substantial gains for a number of reasons other than advances in knowledge. Improvement in the quality of factors (may be caused by spread of education among laborers), economies of scale or better utilization of capacity may lead to substantial gains in TFP without involving an advances in knowledge. Thus, total factor productivity is a broader concept than technological progress.

However, if productivity is increasing in an economy, it means that its factor of production and commodity inputs are manifesting an increase in their output efficiency. The productivity improvements along with the increase in quantities of factors will also be contributing an additional source of output increase.(Brahmananda,1982).Productivity growth is necessary not only to increase output but also to enhance competitiveness of a country. It measures the growth in gross value added that can not be explained by the growth of inputs. The estimation of factor productivity will be very useful to evaluate the variations in the performance of an industry over a period of time. The prosperity of a new developed nation has been attributed mainly to the sustained growth of their total factor productivity (Prescott 1997). Productivity is a performance measure that indicates how effectively an organization converts its resources into its desired products or services. It is a relative measure in that it is used to compare the effectiveness of a country, organization, department, or individual to itself over time for the same operation, or to other countries, organizations, departments, workstations, or individuals. From a systems perspective, productivity indicates how well an organization transforms its inputs into outputs. In manufacturing, productivity is generally stated as a ratio of output to input. Productivity may be expressed as partial measures, multifactor measures, and total measures. Partial productivity measures are used to analyze activities in terms of a single input (e.g., units produced per worker, units produced per plant, units produced per hour, or units produced per quantity of material). Multifactor productivity measures take into account the utilization of multiple inputs (e.g., units of output per the sum of labor, capital, and energy or units of output per the sum of labor and materials). A total measure of productivity expresses the ratio of all outputs produced to all resources used.

Over time the concept of total factor productivity (TFP) started to emerge in economic literature and the emphasis is put more on total factor productivity growth in many studies. Since total factor productivity can account for productivity for the whole set of inputs used in the production process, it is superior to other productivity measures. TFP may also reflect technological improvement realized in a country. The source of TFP growth is not only technological progress but also progress in the quality of inputs or efficiency improvement depending on better organization or institutional restructuring. However, many researchers assert that TFP growth is an approximate measure of technological advancement (Jajri, I, et.al, 2006: 3-8).Solow residual is one of the measures of the total factor productivity ascribing to technological progress. In the standard growth accounting, Solow residual is the part of the growth of national income which cannot be explained by the growth of labour and capital. Hence, many researchers use TFP growth obtaining from the residual of the production function as a measure of technology.

3.3. Econometric model of total factor productivity growth

The partial factor productivity can be calculated by dividing the total output by the quantity of an input. The main problem of using this measurement of productivity is that it ignores the fact that productivity of an input depends on level of other inputs used. The TFP approach overcomes this problem by taking into account the levels of all the inputs used in the production of output. Therefore, in this paper, TFPG is estimated under three input framework applying translog index of TFP as below:

$$\Delta LnTFP(t) = \Delta LnQ(t) - \left[\frac{S_L(t)+S_L(t-1)}{2} x \Delta LnL(t)\right] - \left[\frac{S_K(t)+S_K(t-1)}{2} x \Delta LnK(t)\right] - \left[\frac{S_M(t)+S_M(t-1)}{2} x \Delta LnM(t)\right]$$

Q denotes gross output, L Labour, K Capital, M material including energy input.

$$\Delta Ln\, Q(t) = Ln\, Q(t) - Ln\, Q(t-1)$$
$$\Delta Ln\, L(t) = Ln\, L(t) - Ln\, L(t-1)$$
$$\Delta Ln\, K(t) = Ln\, K(t) - Ln\, K(t-1)$$
$$\Delta LnM(t) = Ln\, M(t) - Ln\, M(t-1)$$

S_K, S_L and S_M being income share of capital, labor and material respectively and these factors add up to unity. ΔLn TFP is the rate of technological change or the rate of growth of TFP.

Using the above equation, growth rates of total factor productivity have been computed for each year. These have been used to obtain an index of TFP in the following way. Let Z denote the index of TFP. The index for the base year, Z(0), is taken as 100. The index for the subsequent years is computed using the following equation:

$$Z(t) / Z(t-1) = \exp[\Delta LnTFP(t)].$$

The translog index of TFP is a discrete approximation to the Divisia index of technical change. It has the advantage that it does not make rigid assumption about elasticity of substitution between factors of production (as done by Solow index). It allows for variable elasticity of substitution. Another advantage of translog index is that it does not require technological progress to be Hicks-neutral. The translog index provides an estimate of the shift of the production function if the technological change is non-neutral.

3.4. Econometric framework for assessing impact of liberalization on TFPG

Although there exists voluminous empirical research work regarding nexus between trade liberalization and factor productivity growth, overviews on the link between liberalization and TFPG find inadequate evidence on this issue, it is as yet a controversial issue and debate is still unsettled. The controversy on the impact of liberalization on TFPG and diverse conclusions resulting from empirical investigations are probably due to differing interpretations of liberalization and openness. These varied empirical results initiate us to investigate further into the links between liberalization and productivity growth of Indian industry.

Grossman and Helpman (1991) argue that technological change can be influenced by a country's openness to trade. Openness to trade provides access to imported inputs which embody new technology and increases the size of the markets facing producers which in turn raises return to innovation and affects a country's research intensive production. Thus, a country's openness leads to improvement in domestic technology helping the production process and becomes more efficient, improves productivity growth.

Benefits from trade to a country's manufacturing sector arise from two sources: The first source is from greater efficiency in production through increased competition and specialization. The second source is from the opportunities that arise to exploit economies of scale in a large market. Reduction in average cost is possible with the access to a large market that encourage larger production runs in the industry .Trade expansion induces firms to increase in size and engage in more plant specialization. In an environment of increased trade, consumers' demand for variety of products can be fulfilled through imports. Access to the world market also means that more products can be produced profitably and this should generate gains from increased product diversity and improve customer welfare (Peterson, 2002:241).

Advocates of trade liberalization aspire to promote productivity gains with the exposure of industries to severe international competition and facilitating access to the international market. They argue that manufacturing units which face foreign competition are forced to adapt. In particular, plants are encouraged to produce closer to the production possibility frontier while the frontier itself will move out faster. Evidence indicates that manufacturing concerns exposed to trade pay higher wages, operate at a higher scale, produce with more capital and achieve higher productivity levels. (Van Biesebroeck, 2003). Productivity growth appears to be directly linked with production of tradable goods. This implies that the benefits from foreign activities are likely to be higher in two areas; firstly, in places where the domestic market is small and foreign sales are a precondition to fully exploit scale economies and secondly, where production technology lags best practice, providing ample scope for productivity improvements through imitation and adaptation of foreign technology. Trade liberalization enables cheaper and easier access to global capital and foreign technologies. Lowering of trade restrictions makes possible the import of capital and intermediate goods which embody superior technology that results cost reduction and also in turn increases productivity growth which uses this product. Therefore, the proponents of a neutral trade regime predict gains in manufacturing productivity from outward looking trade policies. Outward trade orientation brings about familiarity with new technologies induces greater capacity utilization as well as scale benefits via production for export markets and brings about international competition. These in turn are expected to result in productivity improvements in the industrial sector**.**

On the other hand, critics argue that increase in foreign competition may be detrimental to domestic industries if it leads to a closure of factories (Van Biesbroeck, 2003). Rodrik (1991) finds that lower protection or higher import competition reduces a firm's investment in productivity enhancing technological upgrading. This is specially the case when the incentive to invest depends on the firm's output or market share – yet trade liberalization reduces the market share. Deraniyagala and Fine (2000; 98) also argue that the magnitude of gains from trade liberalization could be fairly low. If trade reduces the domestic market shares of the unprotected domestic producers without expanding their international sales, their incentive to invest in improved technology will decrease as protection ceases. This effect reduces the benefits of tariff reductions that are supposed to lower the relative prices of imported capital goods and ease access to foreign technology for domestic firms (Pavcnik, 2000:37).It is also argued that liberalization does not facilitate acquisition of better technology by domestic plants because acquisition is dependent on the flexibility of the domestic labour force.

The principal reforms initiated in the year 1991 included relaxation of import tariffs on most of the goods, removal of quantitative restrictions and liberal terms of entry of foreign players, India's simple average tariff rates were reduced along with reduction of quotas and non tariff barriers. With the extensive relaxation of control over trade, the pace of reforms got momentum over the period 1991-96. After that, the pace of reforms was slowed down. The uneven structure of tariff rates continues to be a cause of concern along with rapid falling trend in tariff rates in the early nineties. The 1991 reforms were much broader in scope and scale and initiated a departure from earlier control regime and permits towards a market oriented regime. The 1985 reforms were piecemeal because it did neither abolish the import license in total nor did it reduce the level of import tariff. As a result of trade liberalization since eighties, Indian economy has become more outward looking with the increase in trade intensity and FDI inflow. Liberalization of foreign investment has increased competition through the entry of foreign firms into the domestic market. The improved performance ended abruptly when the economy slid into a recession in the early 1997 with weak and inefficient firms struggling to cope with increased competition from import and new firms trying to establish themselves in the altered competitive scenario. Rodrik and Subramanian (2004) distinguish the reforms in eighties and nineties by describing the former as 'pro-business' and the latter as 'pro-market'. The eighties' reforms focused on increasing profitability of the existing firms by easing capacity restriction and reducing corporate taxes among other things. The reforms of nineties allowed more competition and paved a way for entry of new domestic firms and MNCs in Indian industries.

The process of liberalization can be linked to the manufacturing productivity. Therefore, trade liberalization is captured by either an explicit measure of liberalization or by a dummy variable capturing a change in the economic policies. The use of dummy variable to demarcate the post-reform period from pre-reform period (as had done earlier by Ahluwalia, 1991; Harrison, 1994; Krishna and Mitra, 1998) is subject to criticism. Dummy variable technique assumes that trade reform was one time phenomenon and it was complete and at the same time it fails to capture that reform has been gradual over time, rather an on-going process. Nevertheless, a dummy variable approach has been taken in the econometric framework to distinguish between the pre and post-reform periods.

In order to understand the impact of liberalization on TFPG more precisely, we also use a piecewise linear regression equation (popularly known as Spline function) which is depicted as follows.

$$\text{Ln } Z_t = A + Bt + B'(t - t_0)\, Dt$$

Where Z_t is TFP. It is assumed that productivity increases linearly with the passage of time until the threshold time period (t_0)[Here, t_0=1990-91 being last year of pre-reform period after which post-liberalization era begins] after which also it changes linearly with the passage of time but at a much steeper rate. Therefore we have a piecewise linear regression consisting of two linear pieces or segments. The productivity function changes it slope at the threshold value (t_0=12). Given the data on TFPG, time period and the value of threshold level, the technique of dummy variables can be used to estimate the slopes of the two segments of the piece-wise linear regression.

4. Result and analysis

4.1. Empirical estimation of TFP growth

Estimation of annual TFP growth rate of Indian electronic industry at aggregate level are presented in Table – 2.

Table 2 Aggregative analysis of TFP Growth rate

Pre- reform Period (1979-'80to 1991-'92)			Post -reform Period (1991-'92 to 2003-'04)		
Year	TFP Indices	Growth rate in TFP (%)	Year	TFP Indices	Growth rate in TFP (%)
1979-80	1	-	1991-92	0.9974	-5.42
80-81	0.9743	-2.57	92-93	1.0062	0.88
81-82	1.0287	5.58	93-94	1.0124	0.62
82-83	0.9649	-6.20	94-95	0.9573	-5.44
83-84	1.0843	12.37	95-96	0.9468	-1.10
84-85	0.9841	-9.24	96-97	0.9798	3.49
85-86	0.9764	-0.78	97-98	0.9614	-1.88
86-87	1.0352	6.02	98-99	0.9258	-3.70
87-88	0.9812	-3.99	99-'00	0.9661	4.35
88-89	0.9758	-0.55	00-01	0.9446	-2.22
89-90	0.9973	2.20	01-02	1.0248	8.49
90-91	1.0546	5.74	02-03	0.9981	-2.60
91-92	0.9974	-5.42	03-04	1.0359	3.79
			04-05	1.0046	-3.02
			05-06	1.0241	1.94
			06-07	1.0176	-0.63
			07-08	0.9983	-1.90
			08-09	1.0457	4.75
Average *Average TFPG during entire period=0.009		0.2633			0.0222

Source: estimated by authors
***computed from semi-log trend**

Table 2 above shows that average total factor productivity growth during pre-reform period is low which is posted as 0.2633 and in post-liberalization period, it further declined to 0.02222.Wide variation in the magnitude of TFPG are found in the estimation. The estimated TFPG of the Indian electronic industry at the aggregate level reveals contradictory rates of productivity growth over years. Over our study period, negative trend in the TFPG in different years is observed at aggregate level. Pradhan and Barik(1999) opined that the low and negative trend in the TFPG is a common feature in most of the developing countries. Average TFPG for the entire period for the entire period computed from semi log trend is positive but very low(0.009). Total Factor productivity growth has reported a negative growth at the rate 0.09286 percent per annum during 1994-95 to1999-2000. However Total Factor Productivity Growth recovered remarkably during the phase (2001-02 to 2005-06). TFPG has reported a positive growth rate of 1.35 percent per annum during this period.

Table 3: Registered Manufacturing of Electronics and IT Hardware Industry (All India)

Characteristics/ year	1990-91	2000-01	2001-02	2003-04	2004-05	2005-06	**CAGR**		
							90-91to 05-06	1990-91 to 2000-01	2000-01 to 2005-06
Number of Factories	1591	1583	1432	1314	1371	1359	-1.05	-0.05	-3.01
Number of Workers	96770	97270	87274	85540	91416	103129	0.43	0.05	1.18
Total Persons Engaged	158991	151130	135387	132941	138300	151102	-0.34	-0.51	0.01
Value of Output at Constant Prices (1993-	802656	1342528	1233887	1557086	3828149	2273716	7.19	5.28	6.13

94=100)									
GVA at Constant Prices (1993-94=100)	198493	263448	262123	301222	654219	490556	6.22	2.87	31.19
Fixed Capital at constant prices (1993-94 =100)	242532	461698	411513	611201	1305165	1043311	10.22	6.65	11.15

Source: Annual Survey of Industries – factory Sector (various years)

The number of factories in the Electronics and IT Hardware Industry is showing a declining trend during the last one and half decade and the rate of decline is higher during the latter period i.e. 2000-01 to 2005-06 than during 1990-91 to 2000-01. The number of person engaged also declined at the rate of 0.34 percent during the period 1990-91 to 2005-06. The decline in employment is greater during in the recent times (2000-01 to 2005-06).It is very encouraging to note that the value of output at constant price has increased during 1990-91 to 2005-06 at a CAGR of 5.28 percent. However, the growth in the value of output during 2000-01 to 2005-06 is higher than that of 1990-91 to 2000-01. This has resulted in an increase in the growth of gross value added at a CAGR of 3.26 percent during 1990-91 to 2004-05. The growth of GVA at constant prices during the period 2000-01 to 2004-05 is also higher than that of 1990-91 to 2000-01 (Table 3).

4.2. Result of Spline function showing impact of liberalization

Using piece wise regression equation by OLS technique, the result of the regression equation is as follows:

$$\text{Ln } Z_t = -0.00221 + 0.00022t - 0.0034\,Dt$$
$$(-0.37) \qquad (-2.17)$$
$$R^2 = 0.38$$

Figures in the parenthesis are t values. As the coefficient of the difference between two time periods is statistically significant at 0.05 level and negative (coefficient being – 0.0034), It can be concluded from the result of spline function that liberalization has its significant negative impact on TFPG during post-reform period. Average growth rate of TFP estimated for pre and post reform periods in table 2 support this result. On the whole, the impact of economic reforms on the TFPG at aggregate level was poor as the negative average rate of TFPG estimated in the pre reform period further increased in the post reform period.

5. Conclusions

This study tries to estimate productivity performance with the help of total factor productivity for the entire period, 1979-80 to 2008-09. The result on the overall productivity displays that TFPG has declined in post-reform period as compared to pre-reform period. The liberalization process is found to have its adverse impact on total factor productivity growth.

Total factor productivity growth displays upward and downward trend over years during both pre and post-reform period .In the said industry, post-reform TFP growth rate reflects dismal declining growth rate which reflects negative impact of liberalization thereon. Given the fact that there exists high degree of intra industrial disparity of TFPG, it is expected that no single explanation for variations in TFPG in each industry group will hold true. Nevertheless, it seems that due to heavy investment in the 1990s, unaccompanied by commensurate expansion of demand, capacity utilization went on worsening in those manufacturing industries. That might have adversely affected the productivity growth.

The negative and significant impact of liberalization on productivity suggests that trade policy should focus on productivity enhancing industrial policies that will, in turn, help firm to enter export market after gaining real competitive edge. Since productivity estimations based on Total Factor Productivity Growth rates have been found quite low in electronics sector, there is a need for substantial up gradation of skill levels of the personnel engaged in the sector and also for the technological progress (R&D activities) in this sector. Moreover, the chances of survival in the highly competitive era are high for more productive firms than less productive firms. The economic theory mentions of different possible reasons for keeping idle capacity in a competitive economy. Therefore, it can be said that the tendency to attribute all economic outcomes in a period, which coincide with economic reforms may not match with the empirical facts. Nevertheless, the industries taken up under our study which keep idle capacity should utilize its capacity to the fullest possible for meeting growing market-demand. India's tariff rates are still among the highest in the world and continue to block India's attractiveness as export platform for energy-intensive manufacturing production. It is also suggested that tariff rates on imported capital goods should be made duty free. It is worth remembering that India has been gradually achieving a high per capita income level so that productivity growth will become more important relative to factor accumulation as a source of economic growth. The unmistakable implication for Indian policymakers is the need to open up more to foreign imports, which will help to bring about institutional and technological progress conducive to TFP growth.

Finally, the present study suffers from certain limitations, which should be taken into account while interpreting the results. We discuss the limitations of our study, which are primarily associated with data limitations. In particular, due to unavailability of the relevant data prior to 1979-80, our empirical analysis is limited to the post-1980 period. There is also a key limitation of the study that it assumes capital to be homogeneous in nature while it has distinct identifiable components. Aggregating these components at historical prices, deflating by a single index number and assuming all components to follow a uniform longevity may induce some amount of bias into the level of capital input. The labour variable used in the study, total persons engaged, is a concept of stock whereas its flow counterpart is man-hours used in the production process. But, the ASI does not provide data on man-hours. The input-output table, which is used for the construction of energy input deflator, is for both the registered and unregistered sector, even though the study covers the registered sector only.

In future applied economic research on India's industrial context, disaggregate analysis with firm level data would ensure more meaningful upshot in order to have a clear insight on this issue which is absent in this study.

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Appendix

A-1 Energy Inputs: - Industry level time series data on cost of fuel of Indian electronic sector have been deflated by suitable deflator (base 1981-82 = 100) to get real energy inputs. An input output table provides the purchase made by manufacturing industry from input output sectors. These transactions are used as the basis to construct weight and then weighted average of price index of different sectors is taken. Taking into consideration 115 sector input -output table (98-99) prepared by CSO, the energy deflator is formed as a weighted average of price indices for various input-output sectors which considers the expenses incurred by manufacturing industries on coal, petroleum products and electricity as given in I-O table for 1998-99. The WIP indices (based 1981- 82) of Coal, Petroleum and Electricity have been used for these three categories of energy inputs. The columns in the absorption matrix for 66 sectors belonging to manufacturing (33- 98) have been added together and the sum so obtained is the price of energy made by the manufacturing industries from various sectors. The column for the relevant sector in the absorption matrix provides the weights used.

A-2 Capital Stock: - The procedure for the arriving at capital stock series is depicted as follows:

First, an implicit deflator for capital stock is formed on NFCS at current and constant prices given in

NAS. The base is shifted to 1981-82 to be consistent with the price of inputs and output.

Second, an estimate of net fixed capital stock (NFCS) for the registered manufacturing sector for 1970-71 (benchmark) is taken from National Accounts Statistics. It is multiplied by a gross-net factor to get an estimate of gross fixed capital stock (GFCS) for the year 1970-71. The rate of gross to net fixed asset available from RBI bulletin was 1.86 in 1970-71 for medium and large public Ltd. companies. Therefore, the NFCS for the registered manufacturing for the benchmark year (1970-71) as reported in NAS is multiplied by 1.86 to get an estimate of GFCS which is deflated by implicit deflator at 1981-82 price to get it in real figure. In order to obtain benchmark estimate of gross real fixed capital stock made for registered manufacturing, it is distributed among various two digit industries (in our study, electronic industry) in proportion of its fixed capital stock reported in ASI, 1970-71)

Third, from ASI data, gross investment in fixed capital in electronic industries is computed for each year by subtracting the book value of fixed in previous year from that in the current year and adding to that figure the reported depreciation on fixed asset in current year. (Symbolically, $I_t = (\beta_t - \beta_{t-1} + D_t) / Pt$) and subsequently it id deflated by the implicit deflator to get real gross investment.

Fourth, the post benchmark real gross fixed capital stock is arrived at by the following procedure. Real gross fixed capital stock (t) = real gross fixed capital stock (t – 1) + real gross investment (t). The annual rate of discarding of capital stock (D_{st}) is assumed to be zero due to difficulty in obtaining data regarding D_{st}.