# Technological Changes in Indian and Japanese Industries in the Era of Globalisation

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**Centre for Studies in International Relations and Development (CSIRD)**
167-B, S. P. Mukherjee Road, Kolkata 700026, India
Phone: (9133) 24630884, 22483769, Fax: (9133) 22483769
Email: csirdindia@yahoo.co.in, Website: www.csird.org.in

# Technological Changes in Indian and Japanese Industries in the Era of Globalisation

**Buddhadeb Ghosh* and Prabir De†**

## 1. Introduction

One of the most prominent features of the world economy over the last few decades has been the rise of production as resultant of liberalization of international trade. Industrialization and expansion of the modern sector have become the basic means of growth and development across the developing countries since World War II. Not only commodities but also factors of production and services are becoming more and more mobile internationally. Globalization means increasing mobility and access to world resources. It also means "competition" in a world economy. In quantitative terms, it speaks of the "outward orientation" of an economy. It is directly beneficial for those industries that are efficient; indirectly, it also creates a positive growth chain through higher productivity thereby generating many new economic activities. In an economy-wide sense, it may work as a poverty removal process also. However, globalization has not only engendered growing interdependence; it has also given rise to marked international inequalities.

Dynamic competitiveness among industries (or what is generally understood by competitiveness of industries over time) has become a determining factor for success or failure of industries. The issue is particularly relevant for countries which have a strong domestic economy, or so to say, whose openness ratio (that is, percentage share of trade in GDP) is low compared to most other nations. To be more specific, USA, Japan and India are only a few such nations, which have an unusually low openness ratio among the relatively larger nations of the world. Moreover, the share of their GDP coming from industry is not unusually high compared to many newly rising nations. It is not their weakness; it is rather the inner strength of their domestic economy that reduces the vulnerability of the economy to

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* Associate Scientist, Economic Research Unit, Indian Statistical Institute, 203, B. T. Road, Kolkata 700 035, India, Email. buddhadeb_ghosh@yahoo.com (corresponding author)

† Associate Fellow, Research and Information System for Developing Countries (RIS), New Delhi. Email: prabirde@hotmail.com

international upheavals.[1] Unusually high dependence on foreign trade with relatively lower domestic market may jeopardize the stability of an economy in an age of globalization; and in that sense, India even being economically poor is such a stable nation which is inherently slow to catch up to the wave of globalization.

In the context of industrial productivity analysis, the most important concern for any economy under globalization is the free mobility of factors of production. Capital is invited in every country while labour is not. But strangely enough, apart from free capital flow across borders, most developed countries except USA and UK have not allowed free mobility of labour. So there is adequate evidence to believe that there is nothing like a ‘general theory’ as far as industrial performance is concerned; this is more so for countries which even if traditionally dependent on foreign trade, do have a strong domestic market. This helps in two fundamental ways: first, it encourages further innovation through higher R & D in the domestic plant; second, it to a large extent insulates the economy from frequent external shocks thereby raising the morale and risk-taking capability of the entrepreneurs. USA, Japan, Germany and UK are certainly some such economies. Among the developing countries, India represents a peculiar syndrome: while it has substantial independence, it does not have an economic system that encourages physical innovations. Let us remind that Japan introduced the first bullet train (“Shinkansen”) in Tokyo in 1964- the same year that hosted Tokyo Olympic. At a time when technology did not travel so easily across countries, these two achievements were of significant strengths to represent the motion which Japan acquired way back in mid-1960s (Smith, 1956 and 1970; Rosovsky, 1961; Ohkawa and Rosovsky, 1973; Youngson, 1972; Yamamura, 1967; Patrick and Rosovsky, 1976; Yamazawa, 1990; Takafusa, 1994). It was therefore very natural that Japan’s per capita income (PCI) was only slightly lower than that of USA till 1965 after which Japan progressed at such a faster pace that by 2001 Japan’s PCI became 1.41 times that of USA (not on PPP basis). On the other hand, India’s PCI was higher than that of China till 1985 after which China started gathering momentum; in 2001, China’s PCI became twice that of India (at constant US$ only). India’s performance in all spheres of economic activities represents quite a slow rate of progression, if at all. But in only one respect, that of “openness” ratio, India can only be compared favourably with only Japan and USA. This only represents India’s dependence on her own domestic market rather than on global market. In another sense, this may also represent how successive Indian governments since her Independence in 1947 till 1991 in their attempt at getting elected through the so-called democratic voting process maintained “protectionism” and a strong public sector. Yet in another sense, structure of foreign trade never played any strong role in determining political power within the nation in India. Hirschman (1945) in a pioneering work has shown how national power and the structure of foreign trade were related in Western countries before the Second World War. Similar findings were also noted subsequently in case of Japan (Patrick and Rosovsky, 1976; Yamazawa, 1990). So 1991 as the starting point of Indian globalization programme is too early to say anything positively after almost 50 years of protected industrial regime.

In terms of the fundamental indicators of economic development at a point in time as at present, India and Japan can not be comfortably compared straightway. One contains all conceivable features of underdevelopment where three centuries still coexist simultaneously in the same environment (Bardhan, 1984; Banerjee and Newman, 1993; Ray, 1998); the other a developed market economy with technological supremacy in many fields. It is therefore natural that Japan's industrial performance should be evaluated within the developed countries framework. Every country is evolving according to its own laws of motion that produces specific types of frictions from time to time depending upon its own institutional framework (North, 1990 and 1994). And the task of the policy-makers is to understand the economic malaise first before making the prescriptions. Very often than not, we come across situations where policy prescriptions abound at the sheer neglect of appropriate diagnosis. Our task here will be to try to understand the basic features of industrial development for both the countries in the context of the present globalization. In a cross-country cross-industry framework, productivity growth appears to be more correlated across industries within one country than across countries within one industry. A substantial fraction of changes in annual productivity can be attributed to nation-specific factors that are common across industries (Costella, 1993).

Given the objective of the present study, we would like to deal mainly with an inter-industry framework. In essence, therefore, by performance under the present globalization era during last 15 years we mean productivity and technological change which will form part of our study. The details of the data and industrial classification along with corresponding names of industries are given in Appendices I, II (India) and III (Japan). Here we consider only 2-digit manufacturing classification. We will eventually show that even 2-digit level of dis-aggregation may not be adequate for understanding the technological and productivity behaviour of industries in actual reality during such a period of growing national specialization across the world.

## 2. Studies on Japanese and Indian Industry: A Review

### 2.1 Japanese Industry

Quite a large number studies (including those by Western economists) on Japanese industries (and firm behaviour) has been published in internationally acclaimed academic journals since the seventies primarily in their search for finding out the analytics of the proximate superiority of Japanese firms. In sharp contrast, studies made after 1991 mainly focused on the very current problems of Japanese industries. Some findings are as follows.

- Over the last two decades, quite a large number of studies have been made by American economists in order to understand the clues to higher productivity in Japanese firms. This process led to the renowned study of "Made in America" report by Dertouzos, Lester and Solow (1989).
- Japan being one of the leaders in productivity, efficiency and innovation in both traditional and modern industries has shown the way of how to get success in Asian conditions and institutional framework (Aoki & Rosenberg, 1989; Porter, 1990).
- But the nature of such studies changed significantly in the 1990s. Kunimune (1999) makes one of the detailed general studies**.** The intensity of the crisis in early 90s was so much internationalized in Western media that the author had to argue "that the notion that Japan caused the Asian currency crisis is not true." Then the author called for "to raise efficiency" and "to be careful about redistribution (not to dampen people's incentives)". Finally, he discussed the "helicopter money" policy as the only way out to generate a positive inflation rate and get the Japanese economy out of its "liquidity trap." As true in all branches of social science, the author rightly conjectured that "Indeed, the stock market could crush in the United States, or there could be a recurrence of the currency crises in neighboring economies" (See also Masato, 2003).
- One should not unlearn that the Japanese model firm is in many ways different from models of the firms as construed by Western economists in a typical neo-classical framework (Mansfield, 1988; Aoki, 1990). Hence in order to understand the behaviour of the Japanese firms one must ascribe special values to qualitative attributes even when functionally modeling. In the context of the post-bubble burst situation, if "outward-oriented" economic policy is undertaken in an appropriate and economics-friendly atmosphere and timing like those of the present East Asian economies, higher productivity growth may lead to sustained economic growth (Kawai, 1994).
- Although computer investment as a proportion to total investment in aggregate manufacturing industries in Japan is less compared to USA, skill-based technological change is at work in the former in recent years. This has resulted in steady rise in the

share of non-production workers that may have affected the demand for production workers and hence the unemployment rate for the masses (Sakurai, 2001).

- Throughout the 90s particularly during late 90s, Japanese employment situation went from bad to worse. More specifically, unemployment in the construction and service industry has greatly contributed to the national unemployment rate. Moreover, industry specific features segment Japanese labour market, and this segmentation has contributed to the worsening unemployment situation in Japan (Abe and Ohta, 2001).
- There is strong evidence in the 90s towards the fact that substantial share of average employment decline can be attributed to the intensified import competition and that the employment sensitivity increases with industry import share, specially in the Yen appreciating recession years (Tomiura, 2003).

On the whole, therefore, even if there appears to have no conflicts in findings concerning the general problems in industry and economy, no major works have so far been found either on the significance of overall technological change as reflected in the relationship between labour productivity and capital per unit of labour or on inter-industry variations in productivity and technological behaviour, or any potential relationship between productivity, technology and employment across industries or changing composition and weight of the respective industries during the most crucial phase of contemporary Japanese economic development during the period of bubble burst.

## 2.2 Indian Industry

Over the last 50 years, India has been partly successful in creating a wide industrial base due mainly to the Second Five Year Plan (the Mahalanobis strategy). But the same strategy is itself responsible for the "sheltered market phenomenon" and the related malaises in her industrial health during the subsequent four decades since the 1960s (Bhagwati and Desai, 1970; Srinivasan, 1975; Chaudhury, 1977; Bardhan, 1984).

- There is sufficient evidence to show that 50 years of protected industrial regime and License Raj (vested interest) have resulted in structural inefficiency and technological retrogression in Indian industry across board (Ahluwalia, 1991; Ghosh and Neogi, 1993 and 1996; Neogi and Ghosh, 1994). Public sector domination in major industries, lower public sector productivity and protected industrial regime were the three main reasons for India's industrial retrogression (Ghosh and Neogi, 1996; Neogi and Ghosh 1998).
- What is more, performance of her industries is not at all encouraging compared to other successful Asian nations (Timmer, 2002).

- In order to provide a competitive economic environment, the Government of India has liberalized the industrial as well as foreign trade sector during the post-1991 period. Casual empiricism suggests that although foreign exchange balance has been satisfactory, Indian industries have not been able to achieve "competitiveness" in the early phase of the post-reform period (Neogi and Ghosh, 1998), and market imperfection has been omnipotent in all spheres of industrial environment.
- Employment in the organized manufacturing sector remained virtually stagnant in the 1980s; but there has been a marked acceleration in the growth of manufacturing employment in general in the 1990s (Goldar, 2000). In sharp contrast, according to Chaudhury (2002) and Nagaraj (2003), economic reforms from 1991 to 1998 have not been able to surpass the value added growth in manufacturing sector that had happened during the first 15 years of planning till the Third Plan in 1960s; also, industrial base has become shallower and employment situation has become worse even in absolute terms, while labour productivity has stagnated and labour intensity has declined progressively. It is also argued that lack of appropriate policy rather than the exogenous factors are responsible for such unfulfilled targets.
- Despite significant performance in software exports over the last 15 years, recession in the USA, high rates of brain drain and also competition from other developing countries have slowed down the recent growth rate of this industry (Kumar, 2001).
- In a recent work Uchikawa (2002) concludes that different industrial sectors (namely capital goods, intermediate goods and consumer goods) have undergone different impacts of globalization; although reforms were effective in strengthening efficiency and competition, their impacts have remained very limited.
- There is prima facie evidence in favour of the fact that external factors in the forms of various infrastructure facilities are primarily responsible for the slow growth of Indian economy in general. Moreover, whatever growth has taken place, regional divergence in both private and public sector industries is the general outcome of India's development scenario over the last half century (Ghosh and De, 1998, 2000, 2004, 2005a; Marjit and Ghosh, 2003) which might be responsible for the overall failure of the economy.
- In sharp contrast to most studies concerning globalization, the roots of India's prolonged stagnation and the glimmer of hope that one notices on the horizon today cannot be fully understood if one ignores the variables that "conventional analysis" has taught us to ignore- the social norms, culture, history, beliefs, adherence to democracy even under acute poverty, and the fabric of social interaction. It would therefore be irrational to ignore unbridgeable heterogeneities in Indian geography, society, language, economy and polity (Bardhan, 1984; Basu, 2001)

- There is also adequate evidence to show that non-price factors like trading infrastructures are responsible for India's failure to establish an export-led growth strategy (Marjit and Roy Chaudhury, 1999; Ghosh and De, 2001; De and Ghosh, 2003).
- On the whole, therefore, there is lack of consensus in findings on Indian industries, which may be marred by mismanagement. But none of these studies provide us with an appropriate inter-industry framework for understanding the dis-aggregated composition of industries, technological behavior and productivity differences across industries and over time during the pre- and post-reform period.

## 3. Measurement of Productivity, Capital and Technological Changes

There is nothing 'absolute' about the performance of a production unit. That is, there is no easy way to designate any performance as 'good' or 'bad' unless compared to some preconceived level, or to that of another unit. It is common to describe the performance of a production unit in terms of 'more or less efficient', and 'more or less productive'. What is the basic difference between these two terms? By the productivity of a production unit one means the ratio of its output to input. Such ratio is easy to compute if the unit uses a single input to produce a single output. But the more likely event is that it uses several inputs to produce several outputs. In that case the inputs and outputs must be aggregated in some economically meaningful way so that the productivity will be a ratio of two scalars. Productivity varies due to differences in the environment in which production occurs, differences in technology, labour and input qualities. On the other hand, by the efficiency of a production unit one means a comparison between the 'observed' and 'optimal' values of its outputs and inputs, where the comparison can take the form of a ratio between observed to maximum potential output obtainable from given inputs (which is called 'production efficiency' or 'technical efficiency'), or the ratio of minimum potential to observed input required to produce the given output (called 'cost efficiency').[2] But unless disaggregated preferably firm level data are available none of these methods will be theoretically sound or very fruitful. For the present study we will be interested in the following approaches.

There are two other broad measures for understanding productivity: (1) labour productivity in the sense of value added per unit of labour, and (2) total factor productivity in the sense of 'unexplained residual' from the contributions of labour and capital. It would be nice to compare estimates derived from the first three approaches in order to find out the robustness of the results in terms of the performance of individual industries. This will be supplemented by a comparative static analysis to which we will come back in details in a later section.

How technological change, capital accumulation and industrial development are linked at the industry level? Economists' concept of technological change is an *ex post* economic characterization where technological possibilities depend in the ultimate analysis on various economic, social and institutional factors. In traditional view, an appropriate technology in one country may not be suitable for another where the factor endowment and institutional setting are fundamentally different. But during last quarter century the world has seen an outright rejection of this traditional view. Availability of any technology from any country has become so easy particularly due to faster mobility of skill and capital that the traditional supremacy of not only the advanced countries but also high technology companies have been on a track of faster decay (Krugman, 1994a and 1994b; Stiglitz, 2003). This has greatly undermined the role of R&D in the LDCs. In this context, technological change in industry may be broadly defined to include (1) advancement of industrial knowledge embodied in new capital goods, (2) adaptive changes introduced at the site of installation, and (3) special tools and information on techniques of scientific human management (Bernal, 1969; Rosenberg, 1976).

### 3.1. Total Factor Productivity Model

One way to measure competitiveness is by the extent of successful export performance. Export success or performance is the resultant of price competitiveness as well as non-price factors. But domestic industrial classification does not generally match trading classification. As is well known, performance of a nation in the present world is meant economic performance, and economic history is concerned with the performance of an economy over time. Such a task can be best served with a theory of economic dynamics comparable to applied general equilibrium analysis. But for all practical purposes the main limitation to do so is the lack of disaggregated time series data for the industries beyond the 2-digit level. In the absence of this, it is better to "examine the performance of economies at various times, and engage in comparative static analysis; but missing is an analytical understanding of the way economies evolve through time" (North, 1994).

There are various existing econometric approaches to study the discussed phenomena. The most popular though less sound approach is to study the total factor productivity (TFP) change of the industries over the concerned time period. Another is to study the nature of the aggregate relationship between productivity and technology among the industries over different time spans that may be called a comparative static analysis (CSA). For productivity comparison one could also use traditional production function approach with the associated technological behaviour.

Total factor productivity, popularly known as TFP, is a supposed measure of technological change in industry over time. It is indeed a very old concept in the classical literature of economic growth and development. It can be expressed as a ratio between real product and real factor inputs used in the production process. Strictly speaking, it was first introduced and used by Jan Tinbergen way back in 1942 in a paper written in German which was not translated into English until 1959. Hence the popular belief traces back its origin to Solow's (1957) influential empirical work on US economy. But quite a large number of studies can be found using this concept of technological development even before Solow (1957). Among these, Johnson (1950), Schmookler (1952), Kendrick (1956), Abramovitz (1956), Rutton (1956) are important.[3]

However, there are two related approaches to the measurement of TFP: the production function approach and the growth accounting approach (of national income) using some fixed shares of inputs. We would like to use the first approach here in terms of a Cobb-Douglas production function. The econometric approach to estimation of TFP requires that we must specify the form of the function. In a single commodity two-factor world, it looks like

$$Y_t = A_t L_t^{\alpha} K_t^{(1-\alpha)} \qquad (1)$$

where $Y_t$, $L_t$, and $K_t$ are output (or, value added), labour input and capital input used in the production process at time 't' respectively. What about $A_t$? It is the economists' technology parameter that conceals within it all the myths about the invisible that governs the shift in production function. Here α is the output elasticity of labour and (1-α) is that of capital. It is obvious that the sum of these two elasticities is one that simply means constant returns to scale.

What about the form of $A_t$? One can define it in many ways. The simplest form is:

$$A_t = A_0 e^{\lambda t} \qquad (2)$$

Which implies that technology progresses at a constant exponential rate of **λ**. Putting this value into (1), we get

$$Y_t = A_0 e^{\lambda t} L_t^{\alpha} K_t^{(1-\alpha)} \qquad (3)$$

Taking logarithm on both sides gives us the final estimable equation:

$$\text{Ln } Y_t = \text{Ln}A_0 + \lambda t + \alpha \text{ Ln } L_t + (1-\alpha) \text{ Ln } K_t \qquad (4)$$

Now it is simple to estimate the technology parameter (λ), the labour elasticity (α) and the capital elasticity (1-α) if we have time series data on Y, K and L. The moment the value of λ is known, we can understand the contribution of technological change to the growth of output. But serious caution is required at this point. The meaning of λ particularly the way it is defined and estimated must be clearly understood before extending it too far as is very common in the existing literature. **λ** is disembodied, exogenous and Hicks-neutral technological progress. 'Disembodied' technological change means that it is not embodied into the factor inputs (labour and/or capital) but it takes place like 'manna from heaven' in the forms of better methods, organization and management of production that improve efficiency of input use. But none of them explicitly presents itself in quantitative form familiar to economists. 'Exogenous' here means that it is independent of the variables utilized in the growth model, that is, capital and labour. Therefore, we are left only with 'time' as the only factor. Quite contrary to this, the entire endogenous literature has been based on various internal (in a sense man-made) factors of production which govern or which have strong influence on productivity, efficiency and technological change. According to this literature, the important factors are education, R & D investment, knowledge and experience, various forms of infrastructure facilities and the like which create a chain of increasing returns (Krugman, 1979; Romer, 1986; Aschauer, 1989a,b; Barro and Sala-i-Martin, 1995).

One special feature of this Hicks-neutral technical change is that it has the uniform effect of increasing the efficiency on both labour and capital, whereas the Harrod-neutral one is labour-augmenting and Solow-neutral is capital-augmenting. Given these distinctions, the meaning of λ should be interpreted in a very cautious way. For all practical purposes, there may be situations when λ may appear to be small, but that should not be taken to mean that "embodied" technological progress is also small. In fact, quite reverse may be the case; λ may be small due to (i) mis-specification of the production function, (ii) failure to take into account both public and private infrastructure capital (that is exogenous factors), (iii) inappropriate policy mix, and the like. On the other hand, a large λ may be the outcome of monopoly factor and related economies of scale, and other unknown factors. On the whole, this λ fails to take into account what we mean by institutional mechanism through social, economic and political infrastructure facilities like incentive system, contract laws, investment climate, education, transport, R & D, energy, openness, governance, and the like.
There is another methodology for estimating TFP change. This second method is strictly contingent upon the assumption of constant factor shares. For example, in this growth accounting approach, share of labour and capital in national income is assumed to remain constant; these shares are used as weights for estimating the "residual" in productivity growth that can not be explained by mere growth of inputs. This TFP by analogy is therefore the same as our technology parameter (λ): the same dis-embodied, exogenous and Hicks-neutral

technological change. This method has one advantage: it can be fruitfully used for cases where data for only terminal years are available. But that too is a heroic assumption as it is too much sensitive to extreme observations. The reader should bear in mind that neither method is full proof. But in the ultimate reality, there is adequate evidence to prove that factor shares remain hardly constant even over the medium time series of more than a decade; this is more so for any developing country like India; and even for Japan and USA, there is always a changing composition of factor shares (Kuznets, 1960; Hicks; 1932). It is also very persuasive to mention that TFP as calculated from the factor share model is a mere "residual", a left out value as an error term that can not be explained by increases in factor inputs. As rightly remarked by Abramovitz (1956), it is simply an "index of our ignorance". We, however, refrain from discussing the growth accounting approach, as we are not going to deal with it here. Chronologically, studies on TFP came to a halt in the Western world from the late 1970s. Economists there became more interested in the detailed breakdown of the inputs in terms of quality considerations, R & D, public investment, education, infrastructure facilities and the like. The recent resurgence in the renewed interest in such an outdated technique may have been influenced by the recent studies of the Young (1992, 1994, 1995) and Krugman's (1994, a and b) two influential articles.

## 4. Empirical Results on TFP Changes

### 4.1 Indian 2-Digit Industries

As discussed in the previous section, we have derived TFP estimates by incorporating a time coefficient into the production function. This has been done in two different ways. First, we have introduced a time dummy for the whole period (1986-87 to 1997-98), and then we have introduced another time dummy from 1991 onwards (1990-91 to 1997-98) in order to test the impact of economic reforms initiated in India in 1991. Let us now turn to Table 1 which presents the TFP changes for both India (Table 1a) and Japan (Table 1b). In this table, TFP1 relates to the whole period and TFP2 relates to post-1991 period. As evident from this table, only six industry groups have come out with statistically significant TFP changes over the period from mid-1980s to late 1990s. But out of these, five industries have achieved statistically significant and strong positive rate of growth (with corresponding t-values in brackets). These industries are: (i) beverages, tobacco & related products (22) with TFP value 0.076 (3.91), (ii) jute & other vegetable fibre textiles (25) with TFP value 0.059 (2.79), (iii) basic metal & alloys industries (33) with TFP value 0.821 (3.60), (iv) metal products & parts excluding machinery & equipments (34) with the highest TFP value 0.976 (4.62), and (v) machinery & equipments (35+36) with TFP value 0.043 (2.21) for the whole period from 1986-87 to 1997-98. The only industry group that has registered statistically significant negative TFP change is wood & wood products including furniture & fixtures (27) with TFP value –0.075 (-1.75). The rest of the industries have not shown any sign of statistically significant TFP change over this whole period.

Given the relative subjectivity of any statistical exercise concerning the valuation of capital, one should not stretch these results too far. Moreover, even if many studies relating to Indian industries consider mid-1980s at the loose beginning of the era of globalization, we defer to draw any conclusion about these industries until we evaluate their performance in the post-reform period. Let us therefore turn to the same table with every second set of estimates corresponding to the same industries (TFP2). In this second set of output, TFP changes have been captured with a break from 1990-91 as the beginning of formal wide spread reforms. Therefore, the value of TFP2 may be supposed to incorporate the impact of economic reforms during the 1990s. Sadly enough, only two groups of industries have recorded statistically significant TFP change. These are: (i) food products (20+21) which have recorded negative TFP change of -0.178 (-2.10) for the period 1990-91 to 1997-98, and (ii) textile products including wearing apparel (26) which has achieved significant positive TFP change of 0.211 (2.06) for the same period. It is puzzling to observe that the earlier set of industries which has recorded significant TFP change from 1986-87 to 1997-98 have not come out to do anything significant during the post-reform period. This has both good and bad message for Indian industries. The bad message is that industrial climate in post-1991 period has not made any universal impact on the performance of 2-digit industries in terms of the most popular measure of performance, TFP. The good message is that since our results have not found at least any substantial negative TFP change, there are still further scopes for evaluation of the industrial climate by the government. Or, in other words, the industrial climate appears to have remained largely unchanged in terms of TFP performance during post-reform period. Or, it requires to be tested whether the industrial climate has become competitive at all. Interestingly enough, even if the thrust on export has not yet become a compulsion in India, positive performance in textile products (26) is reminiscent of India's pre-eminence in this sector for a long time dating back to centuries. On the whole, the industries that have performed well in either case are the same set of industries, which have been there in India for a historically long period of time. Broadly speaking, these are metal products, engineering items (machinery, etc.), textile goods, food products and more encouragingly, the recent partial revival of jute.

A few words about the statistical properties of the TFP findings of these industries may be of interest here. First, introducing the time dummy since 1991 has strengthened the value of TFP change for the whole period. Second, except a few cases, the value adjusted $R^2$ and DW statistics show that the fitted results are not very erratic. Third, in most cases, labour has come out to be an important factor in this set up, whereas capital has not played any significantly positive role.

It is clear from the above analysis that as far as TFP change is concerned, most of the industries have remained unchanged during the post-reform period except food (20+21) and textile (26). Let us wait therefore till the next section where an attempt is made for understanding the general tendency of Indian industrial trajectory in a comparative static framework.

What went wrong with Indian industries in general? It is not easy to answer such broad question in any single research project. India has seen a plethora of changes in economic policies under a mixed economic set up during the first 45 years after her Independence in 1947 till 1991. But success in 'conventional wisdom' has always eluded India. Undertaking a set of right kind of economic policies in principle does not have much to do with implementation in Indian socio-economics. These policy changes can be termed at best as necessary conditions for economic development. But India has never fulfilled what is meant by sufficient conditions for economic progress. This is as true for the aggregate economy as also for industry. This sufficient set of conditions should essentially include an institutional framework which helps the process of implementation of any set of policies in the right time (North, 1994). For example, inefficient planning and half-hearted import substituting industrialization were detected as early as in late 1960s and early 1970s as possible causes of failures (Bhagwati and Desai, 1970; Chaudhury, 1977; Bardhan, 1984). But it took another 20 years for India to switch to market based export-led growth strategy and that too in a half hearted way and at the complete neglect of high rate of unskilled labour force participation.[4] What is more, any study of the industrial sector alone neglecting other important sectors may not give very satisfactory explanation for either overall industrial sector or the individual industries.

### 4.2 Japanese 2-Digit Industries

As is well known, Japan became a member of the OECD group way back in 1964- the same year in which she introduced the Shinkansen along with Tokyo Olympic. Hence, any attempt at evaluating her industrial performance in an unusual phase of last 15 years at the complete neglect of her rise since 1868 would essentially suffer from many limitations (Rosovsky, 1961; Yamamura, 1967; Ohkawa and Rosovsky, 1973; Patrick and Rosovsky, 1976; Yamazawa, 1990; Takafusa, 1994; Odagiri and Goto, 1996). Japan has been passing through her most trying phase since she became a member of the OECD group almost 40 years ago. In that light, the period of the present study for Japanese industries is expected to shed many lights even in an aggregative perspective of 2-digit industry groups. To be more specific, 1991 marks the watershed for contemporary Japanese economic history. The term "bubble burst" is too fashionable. As far as contemporary literature is concerned, 1991 should be identified as a year that actually represented the shaking or jerking of the high growth period preceding that year in Japan. In econometric terminology, this may be termed as a 'correction phenomenon' in long-term growth; in pure economics terminology, a typical lack of total effective demand and liquidity trap situation. In such a perspective, one of our tasks would be to test the standard performance indicators of Japanese industries during this period.

A look at Table 1(b) makes many features obvious. First, out of 23 industry groups (2-digit), as many as 12 groups have registered statistically significant changes in TFP over the period from 1988 to 2001. These industries are: (i) food products (12) (-0.013, -2.71), (ii) beverage, tobacco & feed (13) (0.024, 1.72), (iii) textile & mill products (14) (0.039, 2.16), (iv) apparel & other finished products made from fabrics and similar materials (15) (0.032, 2.08), (v) publishing, printing & allied industries (19) (0.013, 2.09), (vi) rubber products (23) (0.024, 3.01), (vii) ceramic, stone & clay products (25) (0.044, 2.34), (viii) general machinery (29) (0.045, 3.07), (ix) electrical machinery, equipment & parts (30) (0.131, 2.71), (x) transportation equipment (31) (0.078, 7.07), (xi) precision instruments & machinery (32) (0.065, 4.22), and (xii) ordnance & accessories (33) (0.038, 3.05). Interestingly, these are the most cherished industries which have made Japan one of the most developed industrial societies in the world during the 30 years preceding 1991, a major world player and the second largest economy. How many of these industries have experienced positive growth? Interestingly enough, only one industry group, food products (12) has recorded a highly significant but low rate of retrogression since 1988 (-0.013). As can be seen from the table, the rest 11 industries have achieved positive and significant technological breakthrough since 1988; electrical machinery, equipment & parts (30) record the highest growth. The only good candidate that is missing from this list is plastic product (22) that has also a good record of performance in Japan. Questions may be raised as to what happened to Japanese industries in post-1991 period. As usual, in order to test that, we have incorporated an extra time dummy from 1991 onwards to capture the impact of post-1991 period. These results are reported in the same table subsequent to the previous results.

A few words about the post-1991 phenomenon are required here. For the post-1991 period let us look at the second set of results (TFP2) corresponding to each 2-digit industries. As before, unlike Indian industries, here five industrial groups have produced statistically significant TFP changes. Out of them, three groups have recorded negative TFP growth. These are: (i) pulp, paper and products (18), (ii) publishing and printing (19), (iii) ordnance and accessories (33). But none of these industries has played any dominant role in Japanese industrial development. The other two groups have come out with positive TFP growth. These are: (i) food product (12), and (ii) petroleum and coal products (21). Among the rest, many have produced negative TFP growth during post-bubble burst period but none of them is statistically significant. What is more, inclusion of the extra time dummy for capturing the post-1991 phenomenon has not at all changed the behaviour of the other parameters.

## 5. Comparative Static Framework: Inter-Temporal Movements of Industrial Trajectory

Here we try to approach the problem of the relationship between productivity and technological change in terms of an average production function estimated with the help of OLS. Here a technique is said to be efficient (inefficient) when there is an upward (downward) shift of the productivity locus due to adoption of new technology. Figure 1 (a and b) graphically represents this phenomenon clearly in a comparative static framework. The curve $P_1L_1$ represents the average labour productivity locus at time $t_1$ before the adoption of new technology as represented by K/L ratio. If the curve shifts to a higher position, say $P_2L_2$, at time $t_2$ with corresponding higher values of Y/L, we can generally term it as positive technological change. Intuitively, if an average firm shifts from position A on $P_1L_1$ to position C on $P_2L_2$ after the adoption of new technology, this movement can be divided into two parts: from A to B and from B to C. All the points on the old curve $P_1L_1$ can be contemplated as representing newer points on the new curve $P_2L_2$, if there is a thorough shift. The movement from A to B is a natural consequence of higher productivity resulting from higher use of capital per capita, but the movement from B to C is a clear indication of improved technological mechanism even with same level of capital over a different time point. This movement, if occurs in reality, represents a genuine technological breakthrough effected by higher R & D and human ingenuity. Similarly, the downward movement of the productivity locus from $P_1L_1$ to $P_2L_2$ as shown in Figure 1 (b) can be understood as representing a technological retrogression. This is essentially a static framework with some temporal shift. In order to test this simple relationship between Y/L and K/L, we have employed the following non-linear equation for both India and Japan. This will help us understand the direction of the overall movement of the trajectory in the productivity and capital intensity plane over different time spans in the respective countries, when capital labour ratio is changing. We have, therefore, tested the following equation in some selected pair of cross section data set (2-digit) for different time points for both Indian and Japanese industries separately.

$$\mathrm{Ln}\,(y/L) = \alpha + \beta_1\,\mathrm{Ln}(k/L) + \beta_2[\mathrm{Ln}(k/L)]^2 + \delta D + \beta_3\mathrm{Ln}\,(k/L)\,D,$$

where D represents the temporal dummy with D =1 for latter years and D =0 for other years.

According to the standard production function terminology, the above equation implies that in case of a positive association between Y/L (the dependent variable) and K/L (the independent variable), the values of $\beta_1$ and $\delta$ should be greater than zero. More specifically, the value of $\beta_1$ should be positive while that of $\beta_2$ should be negative as along the normal productivity locus Y/L rises at a diminishing rate. If the function shifts upward, – whether parallel or not (depending on the value of $\alpha$ which represents intercept change) - $\delta$ will be positive. But, if $\delta < 0$, then a downward shift is the natural outcome. If it shifts in either southern or southeastern direction, the production process becomes more inefficient. On the other hand, $\beta_3$ represents the slope dummy of the locus. If $\beta_3 <0$, it implies that for higher values of K/L, the production process becomes more inefficient. Positive values of $\delta$ and $\beta_3$ represent opposite movement.

The most popular criticism against this setting is that any such production function should be applied to those types of industries that fall into a common technological domain, that is, industries which do not represent substantial differences in technology. In empirical terms, this means low variance in K/L ratio across the industries. But as will be clear from the subsequent analysis, this variance appears to be high across industries and over time.

## 6. Comparative Static Results on Inter-Temporal Movements of Industrial Trajectory

### 6.1 Indian 2-Digit Industries

As is well known, India officially undertook the economic reforms programme from 1991 onwards. Keeping this in mind, we have divided the period into four different sub-periods spans between (1) 1986-87 and 1990-91, (2) 1986-87 and 1997-98, (3) 1990-91 and 1997-98, and (4) 1990-91 and 1995-96. The first sub-period denotes the performance of the industries immediately before the initiation of economic reforms. The second covers the two terminal points. The third sub-period signifies the crucial phase of economic reforms. The fourth sub-period covers the first five years of the post-reform period. Table 2 presents the values of the coefficients along with both time and slope dummies and the required statistics. It should be clearly stated at the outset for interpreting such comparative static regressions that “time” is a very important phenomenon in this framework. Apart from the role played by the terminal years, it takes a reasonable time to evolve from one type of technological relationship to another type either by going down or going up due to the degree of impact labour productivity gets from capital deepening or by efficient utilization of inputs. In such a prognosis, a 10 to 15 years period is not always adequate to get the results translated into the production coefficients. But if such a period falls under a very crucial phase of a country’s economic and technological evolution, even this apparently short spell may shed some lights on the changing relationship between input and output. In the present case, the time period chosen for India's post-reform evaluation appears to be too short to expect any substantially perceptible changes in terms of the parametric coefficients. As obvious from the table, there is no clear statistically significant impact of the technological parameters as reflected via capital intensity on the productivity of labour. The only exception is the time span between 1986-87 and 1997-98. But this is a very unconventional result compared to a typically decreasing productivity locus. The features will be clearer through the corresponding diagrams (Figure 2a and 2b). There is obviously an exponential shift of the locus with a positive and significant coefficient for the square term of K/L. Moreover, the time dummy has produced significant and positive coefficient, although the slope dummy is negative. This means that there is a rightward tendency of the trajectory with a likely positive impact of rising capital intensity on productivity for industries with higher K/L. This behaviour may have reflected some major positive technological changes in Indian industry from the mid-eighties to late nineties. In a way this may also be interpreted as an impact of earlier attempt at economic liberalization that was undertaken in controlled doze during the mid-eighties. As usual, no clear tendency is observed during the post-reform period, as the time may not be ripe yet. The corresponding estimated curves are also plotted just for understanding, given the fact that the corresponding coefficients have come out to be negative without being statistically significant. In another sense, it may be due to the fact that experimenting 2-digit industries with the help of comparative static framework may not be justified by their heterogeneous technological behaviour (wide variations of K/L ratios) and in such a small spell of time. To be more specific, existing empirical literature on the aforesaid theme should be judged very cautiously.

### 6.2 Japanese 2-Digit Industries

Unlike the Indian results we have found quite different results for Japanese industries. The most surprising finding is that there is no major statistically significant shifts in either intercept dummy or slope dummy in either direction over different time periods from 1988 to 2001, namely between (1) 1988 and 1991, (2) 1988 and 2001, (3) 1991 and 1995, (4) 1991 and 2001, and (5) 1995 and 2001. This may not be unusual as productivity in Japanese industries being essentially of very higher order has not been much affected by the so-called 'bubble burst' phenomena that though have caused significant disorder in the financial market. Unlike Indian industries, here some cases have recorded strong results in terms of their effects through capital intensity. These cases are: 1988 and 2001, 1991 and 2001 and finally between 1995 and 2001. Some comments are worth making here. First, it is interesting to note that in all the three cases there is a statistically significant and positive impact of rising K/L ratio on the productivity of labour. Between 1991 and 2001, it records the strongest relation; also between 1995 (the year of first formal revival in the post-bubble burst period) and 2001, the impact of K/L is very high compared to the terminal years, 1988 and 2001. Second, in all the three cases, particularly between 1991 and 2001, and also between 1995 and 2001, the second derivative of the productivity locus is highly statistically significant with negative coefficients of K/L. This is a typical representation of the diminishing returns to scale.

Third, in none of the cases, there is any significant change in either intercept dummy or slope dummy. This may be taken to mean that there is no significant change in the nature of the relationship between technological variable and productivity during the period from 1988 to 2001. Or, in other words, the popular belief that there is serious retrogression in Japanese manufacturing during the 1990s may not have strong economic foundation. Even if there is no shift in technological parameters, we attempt to represent these relations in terms of some estimated diagrams, which are presented in Figure 3(a, b and c). As it appears from these diagrams, capital intensity and productivity are related in a typical neoclassical way. But none has produced any statistically significant and distinct parametric results. On the whole, use of 2-digit industries may be responsible for not getting any concrete and suggestive results regarding the inherent technological change that might have occurred in post-1991 period. Because such aggregate grouping may not reflect the actual impacts which Japanese industries are undergoing at more dis-aggregated levels. Our future task would be to select industries from more homogeneous 3-digit level or further down.

## 7. Summary and Conclusions

### *Indian Industries*

Only six industry groups in India have come out with statistically significant TFP changes over the period from mid-1980s to late 1990s. Out of these, five industries have achieved strong positive rate of growth for the whole period. These industries are: (a) beverages, tobacco & related products (22), (b) jute & other vegetable fibre textiles (25), (c) basic metal & alloys industries (33), (d) metal products & parts excluding machinery & equipment (34), and (v) machinery & equipment (35+36) for the whole period from 1986-87 to 1997-98. The only industry group that has registered statistically significant negative TFP change is wood & wood products including furniture & fixtures (27). The rest of the industries have not shown any sign of statistically significant TFP change over this whole period.

Our second emphasis was on finding the impact of economic reforms since 1990-91 in Indian industries by incorporating an extra time dummy (TFP2). Here, only two groups of industries have recorded statistically significant TFP change during the post-reform period. These are: (a) food products (20+21) which have recorded negative TFP change for the period 1990-91 to 1997-98, and (b) textile products including wearing apparel (26) which has achieved significant positive TFP change for the same period. It is puzzling to observe that the earlier set of industries which has recorded significant TFP change from 1986-87 to 1997-98 have not come out to do anything significant during the post-reform period. Therefore, it requires to be tested whether the industrial climate has become competitive at all which was the main objective of the liberalization process. Interestingly enough, even if the thrust on export has not yet become a compulsion in India, positive performance of textile products (26) is reminiscent of India's pre-eminence in this sector for a long time dating back to centuries. On the whole, the industries that have performed well in either case are the same set of industries that have been there in India for a historically long period of time. Broadly speaking, these are metal products, engineering items (machinery, etc.), textile goods, food products and more encouragingly, the recent partial revival of jute.

There is no clear statistically significant impact of the technological parameters as reflected via capital intensity on the productivity of labour in Indian industries during this period. The only exception is the time span between 1986-87 and 1997-98. But this is a very unconventional result compared to a typically decreasing productivity locus. There appears to have a significant exponential shift of the productivity locus. Moreover, the time dummy has produced significant and positive coefficient, although the slope dummy is negative. This means that there is a rightward tendency of the trajectory with a likely positive impact of rising capital intensity on productivity for industries with higher K/L. This behaviour may have reflected some major positive technological changes in Indian industry from the mid-eighties to late nineties. In a way this may also be interpreted as an impact of earlier attempt at economic liberalization that was undertaken in controlled doze during the mid-eighties. As usual, no clear tendency is observed during the post-reform period, as the time may not be ripe yet. It may be due to the fact that experimenting 2-digit industries with the help of comparative static framework may not be justified by their heterogeneous technological behaviour (wide variations of K/L ratios) and in such a small spell of time.

All the industries except four groups have registered positive growth rates of labour productivity (Y/L) during the post-reform period. These unsuccessful four groups are (a) wood products (27), (b) paper & related products (28), (c) basic chemicals (31), and (d) storage & communications (74). It may also be noted that there are very large variations in productivity growth across industries. As usual, all the industries have recorded positive growth rates of capital intensity in post-reform period, though pre- and post- reform variations across industries are very high here too. One of the most unexpected features is that growth rate of capital intensity has fallen in the post-reform period for most of the industries.

Therefore, even if post-reform period in India (1990s) has seen higher productivity growth in general, variations across 2-digit industries in all the indicators are too high to draw any general conclusion. On the whole, performance of the leading industries like food, rubber, basic chemical, machinery & equipment and transport equipment has improved in the post-reform period. Under such a situation, the best way to approach the changing composition of Indian industries would be to deal with more dis-aggregated analysis preferably with 3-digit and further down.

### *Japanese Industries*

Out of 23 industry groups (2-digit) in Japan, as many as 12 groups have registered statistically significant changes in TFP over the period from 1988 to 2001. These industries are: (a) food products (12), (b) beverage, tobacco & feed (13), (c) textile & mill products (14), (d) apparel & other finished products made from fabrics and similar materials (15), (e) publishing, printing & allied industries (19), (f) rubber products (23), (g) ceramic, stone & clay products (25), (h) general machinery (29), (i) electrical machinery, equipment & parts (30), (j) transportation equipment (31), (k) precision instruments & machinery (32), and (l) ordnance & accessories (33). Interestingly, these are the most cherished industries which have made Japan one of the most developed industrial societies in the world during the 30 years preceding 1991, a major world player and the second largest economy.

Only one industry group, food product (12) has recorded a highly significant but negative rate TFP change since 1988 (-0.013). The rest 11 industries have achieved positive and significant technological breakthrough since 1988; electrical machinery, equipment & parts (30) record the highest growth. The only good candidate that is missing from this list is plastic product (22) that has also a good record of performance in Japan.

The impact of 1991 bubble burst phenomenon on Japanese industries in post-1991 period is also noteworthy. As before, unlike Indian industries, here five industrial groups have produced statistically significant TFP changes. Out of them, three groups have recorded negative TFP growth. These are (a) pulp, paper and products (18), (b) publishing and printing (19), (c) ordnance and accessories (33). But none of these industries has played any dominant role in Japanese industrial development. The other two groups have come out with positive TFP growth. These are: (a) food product (12), and (b) petroleum and coal products (21).

Among the rest, many have produced negative TFP growth during post-bubble burst period but none is statistically significant.

Unlike Indian results in comparative static framework, we have found quite different results for Japanese industries. The most surprising finding is that there is no major statistically significant shift in either intercept dummy or slope dummy in either direction over different time spans from 1988 to 2001, namely between (a) 1988 and 1991, (b) 1988 and 2001, (c) 1991 and 1995, (d) 1991 and 2001, and (e) 1995 and 2001. This may not be unusual as productivity in Japanese industries being essentially of very higher order has not been much affected by the so-called 'bubble burst' phenomena that though have caused significant disorder in the financial market. But unlike Indian industries, here some cases have recorded very strong results in terms of their effects through capital intensity and its square term. These cases are: 1988 and 2001, 1991 and 2001 and finally between 1995 and 2001.

In none of the cases, there is any significant change in either intercept dummy or slope dummy. This may be taken to mean that there is no significant change in the nature of the relationship between technological variable and productivity during the period from 1988 to 2001. Or, in other words, the popular belief that there is serious retrogression in Japanese manufacturing during the 1990s may not have strong economic foundation.

On the whole, use of 2-digit industries may be responsible for not getting any concrete and suggestive results regarding the inherent technological change that might have occurred in post-1991 period. Because such aggregate grouping may not reflect the actual impacts which Japanese industries have continuously been undergoing at more dis-aggregated levels. Our future task would be to select industries from more homogeneous 3-digit level or further down.

Out of 23 industry groups studied here, 17 industries have recorded positive growth rate of productivity for both the crucial periods, namely 1988 to 1991 and 1991 to 2001. This is certainly a very encouraging observation. Out of these, for as much as six industries, the productivity growth rate itself in real terms has increased during the post-1991 period. These six groups are as follows: (a) beverage, tobacco and feed (13), (b) pulp, paper and products (18), (c) chemical (20), (d) rubber products (23), (e) ceramic, stone and clay products (25), and (f) precision instruments and machinery (32). For the other 11 industries, even though the growth rate has fallen it has remained positive during post-1991 period. The four most important industries among these are: (a) apparel and other finished products (15), (b) publishing industries (19), (c) electrical machinery, equipment and supplies (30), and (d) transportation (31). Note that even after 1991 bubble burst, the growth rate of productivity in electrical machinery industries (30) has remained as high as 4.78% per annum from 1991 to 2001 coming down from 9.48% during 1988 to 1991; that of transportation has been maintained at 2.42% per annum (1991 to 2001) from 6.03% (1988 to 1991).

The important industries which have suffered a set back in terms of productivity growth rate during the bubble burst period are: (a) food products (12), (b) furniture & fixtures (17), (c) petroleum & coal (21), (d) fabricated metal products (28), (e) general machinery (29), and miscellaneous manufacturing (34).

Therefore, industries in both countries have been passing through a very hard time due to increased global competition. Our aggregate data fails to capture the negative impacts of industrial closure on labouring classes, material suppliers as well as small producers. Notwithstanding rising exit and entry among individual firms, in many situations, even if an entire firm is not closed down, numerous departments have been liquidated due to cutthroat competition. All these phenomena have their short run impact on boosting productivity in case of only surviving firms that are recorded in the official database and at the complete neglect of dying firms. A detailed in-depth study of all these emerging phenomena require a well documented firm level data set over time for further investigation into the intensive impact of globalization across industries.

## 8. Future Research Agenda

It is interesting to note that there is far cry for reforms in almost all countries, developed or developing, though the meaning and significance of globalization are completely different in different countries. There is a broad consensus regarding the fact that it is not Manna from Heaven. Some countries are more successful than others is exploiting the opportunities offered by the process of integration through globalization even among many odds (Stiglitz, 2003). The following questions are worth investigating further.

First, there has been tremendous spurt in international research on the relationship between globalization and productivity through either (i) a bias towards skilled worker, or (ii) application of higher technology, or both. If only the first factor is in operation, then there is a potential danger of rising unemployment and wage differential against the unskilled worker, which doubtless represents a larger share of the labour force in developing countries. If only the second factor is in operation, then industries having lower rate of capital accumulation (representing lower technological adaptation) will find it increasingly difficult to compete in a global market. As is well known, Japan has not only the highest cost of living but also one of the highest labour costs in the world. Given their commitment to quality, it appears very difficult for Japanese companies to reduce cost further in a situation of deflationary spiral.

Failure to do so is pushing the ruling Japanese corporations to shift production base away from Japan in their efforts to fight for at least constant market share. While this phenomenon may help the Japanese MNCs who are the world leaders in many fields to face the intense competition under globalization, and to some extent siphon of their profit into the home country, but this may not increase domestic employment in immediate future. Indirectly, it may not at least worsen the already existing glut situation in Japan.

Second, apart from the above, there may be different impact on industries having inherently different labour-intensity and hence on the emerging nature of unemployment. For example, globalization has given rise to rising informal sector in India that is completely outside the purview of the formal manufacturing industries. Therefore, further study should be undertaken at much dis-aggregated level of classification in order to understand the specific differences among industries in the emerging situation.

Third, productivity and competitiveness are ultimately the resultant of a nation's overall infrastructure networks including road, rail, electricity, port facility, housing condition, banking, postal & telecommunication facility, health facility, demographic condition, irrigation facility, outward orientation, labour unrest, macro-economic stability (e.g. inflation rate) and the like. A long period causality test in line with Granger and Engle with aggregate industrial productivity as well as public and private infrastructure capital for both India and Japan are required for understanding the role of infrastructure in a comparable framework. As a corollary, an attempt should also be made to identify the internal and external factors (like transaction costs) responsible for differential industrial performance and competitiveness in a world where physical barriers to trade have virtually diluted.

Finally, given the findings of the present study, we intend to undertake a detailed study with selected 3-digit level for both countries with the help of frontier production function analysis and with more than two factors such that more reliable estimates of efficiency can be estimated.

The present study suffers from many limitations. The main limitation of this study is that under a global economic set up and in a freely flexible exchange market, autarkic estimation of the parameters may not reflect their true international values. Second, both product-mix and technological choices have been passing through a very transitional phase. As a result, the values of the estimated parameters should be cautiously evaluated. Third, as we have failed to include any information on changing institutions and organizations particularly for a developing country like India, the findings should at best be used only as possible signals towards emerging changes. Finally, since we have not dealt with firm level data, aggregate behaviours may not reveal what is actually happening at the level of the firms, either manufacturing or trading. But they would certainly serve as reliable guideline.

## Notes

1. Readers should not have any misjudgment to the effect that the present author intends by any means to place India in the same platform of economic development with Japan and USA. Rather, we have a different view in mind.
2. Interested readers may find it helpful to consult Khumbhakar (1990), Fried, Lovell and Schmidt (1993), and Neogi and Ghosh (1994).
3. In this context, Griliches (1996) remarked: “Solow’s (1957) was not so pioneering, “not the question, nor the data, nor the conclusion…..the ‘new wrinkle’ was the explicit integration of economic theory into such a calculation and the use of calculus”.
4. For critical reviews, see Nadiri (1970, 1972), Kennedy and Thirlwall (1972), Nelson (1981) and Grilishes (1996), and Felipe and Mc Combie (2003).

## Appendix I. Data

**Coverage of Industry and Time:**

The last decade has witnessed a revolutionary change in commodity composition across the world. Given the broad perspective of the present study, we have covered the complete set of 2-digit industries for both India and Japan. Keeping in mind the 1991 economic reforms in India, we have covered the period from 1986-87 to 1999-2000 for the manufacturing total in India, and only up to 1997-98 for 2-digit industries, after which comparable 2-digit data set is not available. On the other hand, the general concern of 1991 as the year of 'bubble burst' in Japan has guided us to choose the period from 1988 to 2001 for Japanese industries- 2-digit as well as manufacturing total. Interestingly, 1991 matches for both the economies as a cut off point but for different reasons.

**Measurement of Capital and Other Deflators:**

We have estimated capital with the help of perpetual capital accumulation method. Interested readers may consult Leontief (1953), Rosovsky (1961), Ohkawa and Rosovsky (1973), Hashim and Dadi (1973) and Roychoudhury (1977) for methodological details. For Japan, capital stock is deflated by the price index of machinery and machine tools. For India, price index for capital formation deflator is used to deflate the accumulated capital stock. Industrial value added for both countries is deflated by the corresponding wholesale prices. Finally, consumer price index number is used to deflate wage rate. Appropriate deflators are used to deflate all other nominal values. The inter-country data are taken from UNO database.

**Japan:**

(1) Industrial data of Japan have been taken from various issues of "Census of Manufactures, Report by Industry, Research and Statistics Department, Economic and Industrial Policy Bureau, Ministry of Economy, Trade and Industry, Tokyo, Japan."

(2) Price data are taken from various issues of "Price Indexes Annual, Research and Statistics Department, Bank of Japan."

**India:**

(1) Industrial data of India have been taken from various issues of Annual Survey of Industries, GOI.

(2) Price data are taken from various issues of Wholesale Prices of India.

## Appendix II. Names and Codes of Indian 2-Digit Industries

| Sr. No. | ISIC | Names | Period of Study |
|---|---|---|---|
| 1 | 0 | All manufacturing | 1986-87 |
| 2 | 20-21 | Food products | 1987-88 |
| 3 | 22 | Beverages, tobacco & related products | 1988-89 |
| 4 | 23 | Cotton textiles | 1989-90 |
| 5 | 24 | Wool, silk & man-made fibre textiles | 1990-91 |
| 6 | 25 | Jute & other vegetable fibre textiles | 1991-92 |
| 7 | 26 | Textile products including wearing apparel | 1992-93 |
| 8 | 27 | Wood & wood products incl. furniture & fixtures | 1993-94 |
| 9 | 28 | Paper, printing, publishing & related product | 1994-95 |
| 10 | 29 | Leather & products & substitutes | 1995-96 |
| 11 | 30 | Rubber, plastic, petroleum & coal products | 1996-97 |
| 12 | 31 | Basic chemicals & chemical products | 1997-98 |
| 13 | 32 | Non-metallic mineral products | 1998-99 |
| 14 | 33 | Basic metal & alloys | 1999-2000 |
| 15 | 34 | Metal products & parts ex mach & equip | |
| 16 | 35-36 | Machinery & equip (non-electrical) | |
| 18 | 37 | Transport equipment & parts | |
| 19 | 38 | Other manufacturing industries incl. scientific | |
| 20 | 40 | Electricity | |
| 21 | 41 | Gas & steam generator & distr. through pipes | |
| 22 | 42 | Water works & supply | |
| 23 | 74 | Storage & warehousing services | |
| 24 | 97 | Repair services | |

### Appendix III. Names and Codes of Japanese Industries

| Sr. No. | ISIC | Name of Industry | Period of Study |
|---|---|---|---|
| 1 | 0 | Manufacturing Total | 1988 |
| 2 | 12 | Manufacture of food | 1989 |
| 3 | 13 | Manufacture of beverages, tobacco & feed | 1990 |
| 4 | 14 | Manufacture of textile & mill products | 1991 |
| 5 | 15 | Apparel & o. finished prod from fabrics & sim. materials | 1992 |
| 6 | 16 | Mfc of lumber & wood products | 1993 |
| 7 | 17 | Mfc of Furniture & fixtures | 1994 |
| 8 | 18 | Mfc of pulp, paper & paper products | 1995 |
| 9 | 19 | Publishing, printing & allied industries | 1996 |
| 10 | 20 | Mfc of chemical & allied products | 1997 |
| 11 | 21 | Mfc of petroleum & coal products | 1998 |
| 12 | 22 | Mfc of plastic products | 1999 |
| 13 | 23 | Mfc of rubber products | 2000 |
| 14 | 24 | Mfc of leather tanning, leather products & fur skins | 2001 |
| 15 | 25 | Mfc of ceramic, stone & clay products | |
| 16 | 26 | Mfc of iron & steel | |
| 17 | 27 | Mfc of non-ferrous metals & products | |
| 18 | 28 | Mfc of fabricated metal products | |
| 19 | 29 | Mfc of general machinery | |
| 20 | 30 | Mfc of electrical machinery, equipment & supplies | |
| 21 | 31 | Mfc of transportation equipment | |
| 22 | 32 | Mfc of precision instruments & machinery | |
| 23 | 33 | Mfc of ordnance & accessories | |
| 24 | 34 | Miscl manufacturing industries | |
| 25 | | | |

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**Table 1(a). Estimation of TFP Growth through Cobb-Douglas Production Function: Indian Manufacturing Industries (2-Digit): 1986-87 to 1997-98**

**$[\ln Y_t = \ln A_0 + \lambda t + \alpha \ln L_t + (1-\alpha) \ln K_t + D_1 t]$**

| IC | Independent Variables | Coefficients | t-stat | Aduj $R^2$ | F value | SEE | DW | SC |
|---|---|---|---|---|---|---|---|---|
| 20+ 21 | Intercept | 17.778 | 1.12 | 0.8964 | 32.72 | 0.09 | 1.64 | 0.17 |
| | Ln(K) | 0.210 | 1.09 | | | | | |
| | Ln(L) | 0.127 | 0.10 | | | | | |
| | **TFP1** | **0.024** | **0.62** | | | | | |
| 20+ 21 | Intercept | 18.37 | 1.38 | 0.9273 | 36.06 | 0.07 | 2.03 | -0.05 |
| | Ln(K) | 0.36 | 2.05 | | | | | |
| | Ln(L) | -0.18 | -0.17 | | | | | |
| | **TFP1** | **0.022** | **0.68** | | | | | |
| | **TFP2** | **-0.178** | **-2.10** | | | | | |
| 22 | Intercept | **26.121** | **6.34** | **0.9370** | **55.57** | **0.06** | **3.31** | **-0.67** |
| | Ln(K) | -0.028 | -0.30 | | | | | |
| | Ln(L) | -0.169 | -0.46 | | | | | |
| | **TFP1** | **0.076** | **3.91** | | | | | |
| 22 | Intercept | **25.96** | **5.87** | 0.9288 | 36.86 | 0.06 | 3.32 | -0.68 |
| | Ln(K) | **-0.03** | **-0.25** | | | | | |
| | Ln(L) | **-0.16** | **-0.42** | | | | | |
| | **TFP1** | **0.077** | **3.66** | | | | | |
| | **TFP2** | **-0.018** | **-0.27** | | | | | |
| 23 | Intercept | 1.505 | 0.05 | 0.6350 | 7.38 | 0.12 | 2.61 | -0.34 |
| | Ln(K) | 0.381 | 0.35 | | | | | |
| | Ln(L) | 1.005 | 1.07 | | | | | |
| | **TFP1** | **-0.027** | **-0.12** | | | | | |
| 23 | Intercept | 3.08 | 0.10 | 0.5861 | 4.89 | 0.13 | 2.58 | -0.32 |
| | Ln(K) | 0.39 | 0.33 | | | | | |
| | Ln(L) | 0.88 | 0.76 | | | | | |
| | **TFP1** | **-0.024** | **-0.10** | | | | | |
| | **TFP2** | **-0.037** | **-0.23** | | | | | |
| 24 | Intercept | **22.935** | **1.71** | **0.8447** | **20.95** | **.15** | **2.47** | **-0.25** |
| | Ln(K) | -0.083 | -0.15 | | | | | |
| | Ln(L) | 0.199 | 0.22 | | | | | |
| | **TFP1** | **0.111** | **0.94** | | | | | |
| 24 | Intercept | 23.11 | 1.62 | 0.8246 | 13.93 | 0.16 | 2.49 | -0.25 |
| | Ln(K) | -0.17 | -0.26 | | | | | |
| | Ln(L) | 0.35 | 0.31 | | | | | |
| | **TFP1** | **0.122** | **0.93** | | | | | |
| | **TFP2** | **0.057** | **0.28** | | | | | |
| 25 | Intercept | **18.912** | **3.56** | **0.6254** | **7.12** | **0.11** | **1.16** | **0.38** |
| | Ln(K) | -0.131 | -1.21 | | | | | |
| | Ln(L) | 0.509 | 1.42 | | | | | |
| | **TFP1** | **0.059** | **2.79** | | | | | |

| IC | Independent Variables | **Coefficients** | **t-stat** | Aduj R2 | F value | SEE | DW | SC |
|---|---|---|---|---|---|---|---|---|
| 25 | Intercept | **19.78** | **3.65** | 0.6209 | 5.51 | 0.11 | 1.45 | 0.18 |
| | Ln(K) | **-0.12** | **-1.06** | | | | | |
| | Ln(L) | **0.41** | **1.10** | | | | | |
| | **TFP1** | **0.071** | **2.89** | | | | | |
| | **TFP2** | **-0.121** | **-0.95** | | | | | |
| 26 | Intercept | 6.040 | 1.16 | 0.9688 | 114.81 | 0.11 | 1.58 | 0.19 |
| | Ln(K) | 0.295 | 1.08 | | | | | |
| | Ln(L) | 0.879 | 1.66 | | | | | |
| | **TFP1** | **-0.021** | **-0.32** | | | | | |
| 26 | Intercept | 5.45 | 2.45 | 0.9778 | 122.03 | 0.09 | 2.54 | -0.28 |
| | Ln(K) | 0.20 | 0.84 | | | | | |
| | Ln(L) | 1.11 | 2.41 | | | | | |
| | **TFP1** | **-0.044** | **-0.80** | | | | | |
| | **TFP2** | **0.211** | **2.06** | | | | | |
| 27 | Intercept | **29.07** | **2.04** | **0.2123** | **1.99** | **0.19** | **2.03** | **-0.04** |
| | Ln(K) | 0.43 | 1.92 | | | | | |
| | Ln(L) | -1.42 | -1.20 | | | | | |
| | **TFP1** | **-0.075** | **-1.71** | | | | | |
| 27 | Intercept | 14.44 | 0.41 | 0.1266 | 1.40 | 0.20 | 2.06 | -0.04 |
| | Ln(K) | 0.45 | 1.88 | | | | | |
| | Ln(L) | -0.15 | -0.05 | | | | | |
| | **TFP1** | **-0.116** | **-1.16** | | | | | |
| | **TFP2** | **0.240** | **0.46** | | | | | |
| 28 | Intercept | **9.63** | **1.28** | **0.7524** | **12.13** | **0.10** | **1.65** | **0.10** |
| | Ln(K) | 0.13 | 0.57 | | | | | |
| | Ln(L) | 0.89 | 1.97 | | | | | |
| | **TFP1** | **0.006** | **0.14** | | | | | |
| 28 | Intercept | 6.75 | 0.87 | 0.7619 | 9.80 | 0.10 | 2.04 | -0.08 |
| | Ln(K) | 0.24 | 1.00 | | | | | |
| | Ln(L) | 0.91 | 2.05 | | | | | |
| | **TFP1** | **-0.031** | **-0.56** | | | | | |
| | **TFP2** | **0.132** | **1.15** | | | | | |
| 29 | Intercept | 9.82 | 1.39 | 0.8405 | 20.33 | 0.17 | 1.64 | 0.18 |
| | Ln(K) | 0.61 | 0.81 | | | | | |
| | Ln(L) | -0.06 | -0.04 | | | | | |
| | **TFP1** | **-0.025** | **-0.22** | | | | | |
| 29 | Intercept | 13.45 | 1.73 | 0.8441 | 15.89 | 0.17 | 2.04 | -0.03 |
| | Ln(K) | 0.27 | 0.34 | | | | | |
| | Ln(L) | 0.24 | 0.17 | | | | | |
| | **TFP1** | **0.011** | **0.09** | | | | | |
| | **TFP2** | **0.229** | **1.09** | | | | | |
| 30 | Intercept | 6.95 | 0.51 | 0.9698 | 118.71 | 0.12 | 2.19 | -0.27 |
| | Ln(K) | 0.68 | 0.85 | | | | | |
| | Ln(L) | 0.09 | 0.20 | | | | | |
| | **TFP1** | **-0.016** | **-0.09** | | | | | |

| IC | Independent Variables | Coefficients | t-stat | Aduj $R^2$ | F value | SEE | DW | SC |
|---|---|---|---|---|---|---|---|---|
| 30 | Intercept | -0.69 | -0.04 | 0.9671 | 81.88 | 0.13 | 2.36 | -0.37 |
| | Ln(K) | 1.08 | 1.01 | | | | | |
| | Ln(L) | -0.07 | -0.13 | | | | | |
| | **TFP1** | **-0.097** | **-0.43** | | | | | |
| | **TFP2** | **-0.117** | **-0.59** | | | | | |
| 31 | Intercept | 1.65 | 0.17 | 0.5767 | 5.99 | 0.16 | 2.88 | -0.72 |
| | Ln(K) | 0.61 | 1.62 | | | | | |
| | Ln(L) | 0.61 | 3.74 | | | | | |
| | **TFP1** | **-0.043** | **-0.81** | | | | | |
| 31 | Intercept | -0.15 | -0.02 | 0.5455 | 4.30 | 0.16 | 2.83 | -0.66 |
| | Ln(K) | 0.66 | 1.64 | | | | | |
| | Ln(L) | 0.68 | 3.49 | | | | | |
| | **TFP1** | **-0.061** | **-1.00** | | | | | |
| | **TFP2** | **0.136** | **0.67** | | | | | |
| 32 | Intercept | -0.24 | -0.01 | 0.7920 | 14.96 | 0.15 | 1.73 | 0.13 |
| | Ln(K) | 0.24 | 0.58 | | | | | |
| | Ln(L) | 1.42 | 0.83 | | | | | |
| | **TFP1** | **0.034** | **0.50** | | | | | |
| 32 | Intercept | 1.76 | 0.07 | 0.7684 | 10.12 | 0.16 | 1.70 | 0.15 |
| | Ln(K) | 0.28 | 0.64 | | | | | |
| | Ln(L) | 1.18 | 0.63 | | | | | |
| | **TFP1** | **0.020** | **0.25** | | | | | |
| | **TFP2** | **0.078** | **0.43** | | | | | |
| | | | | | | | | |
| 33 | Intercept | **96.89** | **2.15** | **0.5326** | **5.18** | **0.40** | **1.47** | **0.06** |
| | Ln(K) | -4.31 | -3.73 | | | | | |
| | Ln(L) | 2.70 | 1.07 | | | | | |
| | **TFP1** | **0.821** | **3.60** | | | | | |
| 33 | Intercept | **118.32** | **2.59** | 0.5760 | 4.74 | 0.38 | 1.40 | 0.14 |
| | Ln(K) | **-5.17** | **-4.06** | | | | | |
| | Ln(L) | **2.74** | **1.14** | | | | | |
| | **TFP1** | **0.919** | **4.01** | | | | | |
| | **TFP2** | **0.645** | **1.35** | | | | | |
| 34 | Intercept | **145.95** | **5.90** | **0.6888** | **9.12** | **0.31** | **2.80** | **-0.55** |
| | Ln(K) | -3.47 | -3.88 | | | | | |
| | Ln(L) | -3.80 | -2.02 | | | | | |
| | **TFP1** | **0.976** | **4.62** | | | | | |
| 34 | Intercept | **146.34** | **5.52** | 0.6454 | 6.01 | 0.34 | 2.76 | -0.51 |
| | Ln(K) | **-3.53** | **-3.34** | | | | | |
| | Ln(L) | **-3.71** | **-1.77** | | | | | |
| | **TFP1** | **0.983** | **4.27** | | | | | |
| | **TFP2** | **0.059** | **0.15** | | | | | |
| 35+ 36 | Intercept | **10.02** | **1.27** | **0.9585** | **85.61** | **0.06** | **1.85** | **0.05** |
| | Ln(K) | 0.19 | 1.63 | | | | | |
| | Ln(L) | 0.76 | 1.30 | | | | | |
| | **TFP1** | **0.043** | **2.21** | 0.9589 | 65.15 | 0.06 | 1.97 | -0.03 |

| IC | Independent Variables | Coefficients | t-stat | Aduj $R^2$ | F value | SEE | DW | SC |
|---|---|---|---|---|---|---|---|---|
| 35+ 36 | Intercept | **8.84** | **1.12** | | | | | |
| | Ln(K) | **0.13** | **0.99** | | | | | |
| | Ln(L) | **0.95** | **1.56** | | | | | |
| | **TFP1** | **0.058** | **2.40** | | | | | |
| | **TFP2** | **-0.082** | **-1.04** | | | | | |
| 37 | Intercept | -7.64 | -0.85 | 0.9540 | 77.02 | 0.08 | 1.77 | 0.06 |
| | Ln(K) | 0.30 | 0.90 | | | | | |
| | Ln(L) | 1.90 | 4.31 | | | | | |
| | **TFP1** | **0.005** | **0.09** | | | | | |
| 37 | Intercept | -11.66 | -0.99 | 0.9497 | 52.90 | 0.08 | 1.75 | 0.03 |
| | Ln(K) | 0.04 | 1.02 | | | | | |
| | Ln(L) | 2.01 | 4.00 | | | | | |
| | **TFP1** | **-0.023** | **-0.29** | | | | | |
| | **TFP2** | **0.063** | **0.56** | | | | | |
| 38 | Intercept | -1.46 | -0.11 | 0.9295 | 49.35 | 0.14 | 2.08 | -0.09 |
| | Ln(K) | 0.01 | 0.04 | | | | | |
| | Ln(L) | 2.09 | 1.95 | | | | | |
| | **TFP1** | **0.017** | **0.19** | | | | | |
| 38 | Intercept | -5.19 | -0.36 | 0.9271 | 35.98 | 0.15 | 2.61 | -0.36 |
| | Ln(K) | -0.02 | -0.11 | | | | | |
| | Ln(L) | 2.49 | 2.10 | | | | | |
| | **TFP1** | **-0.016** | **-0.17** | | | | | |
| | **TFP2** | **0.150** | **0.86** | | | | | |

**Table 1(b). Estimation of TFP Growth through Cobb-Douglas Production Function: Japanese Manufacturing Industries (2-Digit): 1988 to 2001**

**[$Ln\ Y_t = LnA_0 + \lambda t + \alpha\ Ln\ L_t + (1\text{-}\alpha)\ Ln\ K_t + D_1\ t$]**

| IC | Independent Variables | Coefficients | t-stat | Adjuj $R^2$ | F value | SEE | DW | SC |
|---|---|---|---|---|---|---|---|---|
| **12** | Intercept | **5.59** | **1.15** | **0.8751** | **31.35** | **0.02** | **2.28** | **-0.33** |
| | Ln(K) | 0.05 | 2.85 | | | | | |
| | Ln(L) | 1.68 | 4.49 | | | | | |
| | **TFP1** | **-0.013** | **-2.71** | | | | | |
| **12** | Intercept | **12.81** | **2.06** | 0.8942 | 28.46 | 0.02 | 1.80 | -0.04 |
| | Ln(K) | **0.03** | **1.64** | | | | | |
| | Ln(L) | **1.18** | **2.61** | | | | | |
| | **TFP1** | **-0.009** | **-1.83** | | | | | |
| | **TFP2** | **0.039** | **1.68** | | | | | |
| 13 | Intercept | **21.20** | **2.66** | **0.9448** | **75.11** | **0.02** | **2.27** | **-0.25** |
| | Ln(K) | 0.12 | 0.33 | | | | | |
| | Ln(L) | 0.33 | 0.70 | | | | | |
| | **TFP1** | **0.024** | **1.72** | | | | | |
| 13 | Intercept | **18.22** | **1.53** | 0.9395 | 51.42 | 0.02 | 2.22 | -0.22 |
| | Ln(K) | **0.22** | **0.46** | | | | | |
| | Ln(L) | **0.34** | **0.69** | | | | | |
| | **TFP1** | **0.023** | **1.58** | | | | | |
| | **TFP2** | **-0.010** | **-0.35** | | | | | |
| 14 | Intercept | **14.54** | **3.72** | **0.9890** | **389.76** | **0.02** | **2.02** | **-0.03** |
| | Ln(K) | -0.10 | -0.43 | | | | | |
| | Ln(L) | 1.32 | 5.25 | | | | | |
| | **TFP1** | **0.039** | **2.16** | | | | | |
| 14 | Intercept | **17.10** | **2.96** | 0.9883 | 274.41 | 0.02 | 2.20 | -0.11 |
| | Ln(K) | **-0.15** | **-0.60** | | | | | |
| | Ln(L) | **1.23** | **3.50** | | | | | |
| | **TFP1** | **0.030** | **1.28** | | | | | |
| | **TFP2** | **0.023** | **0.62** | | | | | |
| 15 | **Intercept** | **14.68** | **5.10** | **0.9802** | **215.75** | **0.03** | **1.55** | **0.22** |
| | Ln(K) | -0.07 | -0.38 | | | | | |
| | Ln(L) | 1.18 | 5.88 | | | | | |
| | **TFP1** | **0.032** | **2.08** | | | | | |
| 15 | Intercept | **16.75** | **5.39** | 0.9821 | 178.85 | 0.03 | 1.92 | 0.02 |
| | Ln(K) | **-0.07** | **-0.39** | | | | | |
| | Ln(L) | **1.01** | **4.56** | | | | | |
| | **TFP1** | **0.017** | **0.92** | | | | | |
| | **TFP2** | **0.066** | **1.42** | | | | | |
| 16 | Intercept | **28.67** | **2.56** | **0.8420** | **24.09** | **0.03** | **1.83** | **0.06** |
| | Ln(K) | -0.48 | -0.96 | | | | | |
| | Ln(L) | 1.03 | 3.44 | | | | | |
| | **TFP1** | **0.022** | **1.66** | | | | | |

| IC | Independent Variables | Coefficients | t-stat | Adj $R^2$ | F value | SEE | DW | SC |
|---|---|---|---|---|---|---|---|---|
| 16 | Intercept | **36.57** | **1.80** | 0.8287 | 16.72 | 0.04 | 1.69 | 0.13 |
| | Ln(K) | **-0.78** | **-0.95** | | | | | |
| | Ln(L) | **1.07** | **3.31** | | | | | |
| | **TFP1** | **0.023** | **1.65** | | | | | |
| | **TFP2** | **0.030** | **0.47** | | | | | |
| 17 | Intercept | 19.70 | 3.69 | 0.8862 | 34.74 | 0.05 | 1.56 | 0.20 |
| | Ln(K) | -0.14 | -0.44 | | | | | |
| | Ln(L) | 1.03 | 2.36 | | | | | |
| | **TFP1** | -0.002 | -0.13 | | | | | |
| 17 | Intercept | 29.85 | 2.56 | 0.8857 | 26.19 | 0.05 | 1.56 | 0.19 |
| | Ln(K) | -0.63 | -1.06 | | | | | |
| | Ln(L) | 1.32 | 2.51 | | | | | |
| | **TFP1** | **0.005** | **0.28** | | | | | |
| | **TFP2** | **0.103** | **0.98** | | | | | |
| 18 | Intercept | 20.44 | 1.33 | 0.1663 | 1.87 | 0.03 | 1.06 | 0.46 |
| | Ln(K) | -0.12 | -0.12 | | | | | |
| | Ln(L) | 0.96 | 0.78 | | | | | |
| | **TFP1** | **0.013** | **0.53** | | | | | |
| 18 | Intercept | -25.43 | -0.94 | 0.3490 | 2.74 | 0.03 | 1.79 | 0.09 |
| | Ln(K) | 2.06 | 1.45 | | | | | |
| | Ln(L) | -0.53 | -0.40 | | | | | |
| | **TFP1** | **-0.019** | **-0.69** | | | | | |
| | **TFP2** | **-0.122** | **-1.95** | | | | | |
| 19 | Intercept | **17.30** | **5.91** | **0.9184** | **49.74** | **0.02** | **1.42** | **0.18** |
| | Ln(K) | 0.07 | 0.33 | | | | | |
| | Ln(L) | 0.77 | 2.08 | | | | | |
| | **TFP1** | **0.013** | **2.09** | | | | | |
| 19 | Intercept | 9.93 | 2.22 | 0.9373 | 49.56 | 0.02 | 1.56 | 0.13 |
| | Ln(K) | 0.22 | 1.07 | | | | | |
| | Ln(L) | 1.02 | 2.94 | | | | | |
| | **TFP1** | **0.014** | **2.49** | | | | | |
| | **TFP2** | **-0.071** | **-2.01** | | | | | |
| 20 | Intercept | 17.71 | 1.01 | 0.6114 | 7.82 | 0.04 | 1.17 | 0.37 |
| | Ln(K) | -0.03 | -0.03 | | | | | |
| | Ln(L) | 1.02 | 1.35 | | | | | |
| | **TFP1** | **0.019** | **1.04** | | | | | |
| 20 | Intercept | 18.18 | 0.83 | 0.5683 | 5.28 | 0.04 | 1.17 | 0.37 |
| | Ln(K) | -0.04 | -0.04 | | | | | |
| | Ln(L) | 1.00 | 1.13 | | | | | |
| | **TFP1** | **0.018** | **0.93** | | | | | |
| | **TFP2** | **0.003** | **0.04** | | | | | |

| IC | Independent Variables | Coefficients | t-stat | Adjuj $R^2$ | F value | SEE | DW | SC |
|---|---|---|---|---|---|---|---|---|
| 21 | Intercept | -61.93 | -1.03 | 0.6571 | 9.30 | 0.27 | 1.44 | 0.27 |
| | Ln(K) | 1.88 | 0.77 | | | | | |
| | Ln(L) | 3.46 | 2.19 | | | | | |
| | **TFP1** | **0.015** | **0.25** | | | | | |
| 21 | Intercept | -96.90 | -1.76 | 0.7397 | 10.24 | 0.23 | 1.67 | 0.16 |
| | Ln(K) | 4.18 | 1.74 | | | | | |
| | Ln(L) | 0.33 | 0.16 | | | | | |
| | **TFP1** | **-0.136** | **-1.49** | | | | | |
| | **TFP2** | **0.695** | **2.04** | | | | | |
| 22 | Intercept | 11.30 | 2.32 | 0.9185 | 49.21 | 0.02 | 1.81 | -0.15 |
| | Ln(K) | 0.30 | 1.02 | | | | | |
| | Ln(L) | 0.69 | 1.73 | | | | | |
| | **TFP1** | **0.007** | **1.23** | | | | | |
| 22 | Intercept | -2.57 | -0.25 | 0.9278 | 42.78 | 0.02 | 2.00 | 0.02 |
| | Ln(K) | 0.64 | 1.80 | | | | | |
| | Ln(L) | 1.01 | 2.34 | | | | | |
| | **TFP1** | **0.004** | **0.70** | | | | | |
| | **TFP2** | **-0.087** | **-1.51** | | | | | |
| 23 | Intercept | **15.64** | **4.11** | **0.3617** | **3.46** | **0.04** | **1.13** | **0.42** |
| | Ln(K) | -0.01 | -0.11 | | | | | |
| | Ln(L) | 1.05 | 3.16 | | | | | |
| | **TFP1** | **0.024** | **3.01** | | | | | |
| 23 | Intercept | 10.66 | 1.64 | 0.3557 | 2.79 | 0.04 | 0.91 | 0.55 |
| | Ln(K) | 0.01 | 0.02 | | | | | |
| | Ln(L) | 1.46 | 2.66 | | | | | |
| | **TFP1** | **0.039** | **2.27** | | | | | |
| | **TFP2** | **-0.065** | **-0.95** | | | | | |
| 24 | Intercept | 7.68 | 1.33 | 0.9783 | 196.01 | 0.04 | 1.68 | -0.02 |
| | Ln(K) | 0.38 | 1.13 | | | | | |
| | Ln(L) | 0.84 | 2.61 | | | | | |
| | **TFP1** | **-0.007** | **-0.36** | | | | | |
| 24 | Intercept | 2.76 | 0.39 | 0.9791 | 153.33 | 0.04 | 1.83 | -0.17 |
| | Ln(K) | 0.55 | 1.51 | | | | | |
| | Ln(L) | 0.92 | 2.85 | | | | | |
| | **TFP1** | **0.004** | **0.17** | | | | | |
| | **TFP2** | **-0.076** | **-1.19** | | | | | |
| 25 | Intercept | **37.44** | **2.57** | **0.9..5** | **40.22** | **0.03** | **1.66** | **0.13** |
| | Ln(K) | -1.13 | -1.72 | | | | | |
| | Ln(L) | 1.96 | 4.25 | | | | | |
| | **TFP1** | **0.044** | **2.34** | | | | | |
| 25 | Intercept | **24.89** | **1.36** | 0.9026 | 31.12 | 0.03 | 2.00 | -0.03 |
| | Ln(K) | **-0.75** | **-1.01** | | | | | |
| | Ln(L) | **2.06** | **4.43** | | | | | |
| | **TFP1** | **0.046** | **2.48** | | | | | |
| | **TFP2** | **-0.055** | **-1.10** | | | | | |
| | | | | | | | | |

| IC | Independent Variables | Coefficients | t-stat | Aduj $R^2$ | F value | SEE | DW | SC |
|---|---|---|---|---|---|---|---|---|
| 26 | Intercept | 45.62 | 1.98 | 0.6401 | 8.71 | 0.06 | 1.49 | 0.25 |
| | Ln(K) | -0.76 | -0.88 | | | | | |
| | Ln(L) | 0.53 | 1.06 | | | | | |
| | **TFP1** | **0.002** | **0.08** | | | | | |
| 26 | Intercept | 41.20 | 1.60 | 0.6102 | 6.09 | 0.07 | 1.59 | 0.20 |
| | Ln(K) | -0.75 | -0.84 | | | | | |
| | Ln(L) | 0.86 | 1.00 | | | | | |
| | **TFP1** | **0.018** | **0.44** | | | | | |
| | **TFP2** | **-0.056** | **-0.48** | | | | | |
| 27 | Intercept | 3.55 | -0.26 | 0.7718 | 15.66 | 0.04 | 1.96 | -0.03 |
| | Ln(K) | 0.62 | 1.18 | | | | | |
| | Ln(L) | 1.16 | 4.30 | | | | | |
| | **TFP1** | **0.012** | **0.76** | | | | | |
| 27 | Intercept | -8.51 | -0.58 | 0.7684 | 11.79 | 0.04 | 2.32 | -0.22 |
| | Ln(K) | 0.69 | 1.30 | | | | | |
| | Ln(L) | 1.41 | 3.71 | | | | | |
| | **TFP1** | **0.018** | **1.05** | | | | | |
| | **TFP2** | **-0.057** | **-0.92** | | | | | |
| 28 | Intercept | 8.34 | 1.27 | 0.8999 | 39.95 | 0.03 | 1.64 | 0.12 |
| | Ln(K) | -0.11 | -0.27 | | | | | |
| | Ln(L) | 1.87 | 3.62 | | | | | |
| | **TFP1** | **0.019** | **1.37** | | | | | |
| 28 | Intercept | 7.11 | 0.70 | 0.8891 | 27.06 | 0.03 | 1.65 | 0.12 |
| | Ln(K) | -0.07 | -0.14 | | | | | |
| | Ln(L) | 1.87 | 3.44 | | | | | |
| | **TFP1** | **0.019** | **1.30** | | | | | |
| | **TFP2** | **-0.009** | **-0.17** | | | | | |
| **29** | Intercept | **31.52** | **2.62** | **0.6707** | **9.82** | **0.05** | **0.92** | **0.54** |
| | Ln(K) | -1.28 | -2.17 | | | | | |
| | Ln(L) | 2.69 | 4.60 | | | | | |
| | **TFP1** | **0.045** | **3.07** | | | | | |
| **29** | Intercept | 51.10 | 1.46 | 0.6480 | 6.98 | 0.05 | 0.82 | 0.59 |
| | Ln(K) | -2.04 | -1.45 | | | | | |
| | Ln(L) | 2.92 | 4.08 | | | | | |
| | **TFP1** | **0.053** | **2.59** | | | | | |
| | **TFP2** | **0.078** | **0.60** | | | | | |
| **30** | Intercept | **69.09** | **1.71** | **0.8367** | **23.19** | **0.07** | **1.45** | **0.27** |
| | Ln(K) | -2.62 | -1.50 | | | | | |
| | Ln(L) | 2.85 | 2.50 | | | | | |
| | **TFP1** | **0.131** | **2.71** | | | | | |
| **30** | Intercept | **27.75** | **0.43** | 0.8312 | 17.01 | 0.07 | 1.71 | 0.14 |
| | Ln(K) | **-1.25** | **-0.51** | | | | | |
| | Ln(L) | **2.82** | **2.43** | | | | | |
| | **TFP1** | **0.115** | **2.18** | | | | | |
| | **TFP2** | **-0.099** | **-0.82** | | | | | |

| IC | Independent Variables | Coefficients | t-stat | Aduj $R^2$ | F value | SEE | DW | SC |
|---|---|---|---|---|---|---|---|---|
| **31** | Intercept | **54.31** | **6.13** | **0.8938** | **37.48** | **0.03** | **2.47** | **-0.26** |
| | Ln(K) | -2.48 | -4.91 | | | | | |
| | Ln(L) | 3.71 | 6.49 | | | | | |
| | **TFP1** | **0.078** | **7.07** | | | | | |
| **31** | Intercept | **45.27** | **2.71** | 0.8872 | 26.57 | 0.03 | 2.25 | -0.14 |
| | Ln(K) | **-2.21** | **-3.31** | | | | | |
| | Ln(L) | **3.78** | **6.31** | | | | | |
| | **TFP1** | **0.079** | **6.88** | | | | | |
| | **TFP2** | **-0.051** | **-0.65** | | | | | |
| **32** | Intercept | **44.51** | **3.67** | **0.6115** | **7.82** | **0.04** | **1.39** | **0.28** |
| | Ln(K) | -1.46 | -2.52 | | | | | |
| | Ln(L) | 2.02 | 4.35 | | | | | |
| | **TFP1** | **0.065** | **4.22** | | | | | |
| **32** | Intercept | **27.01** | **1.69** | 0.6602 | 7.32 | 0.04 | 1.87 | 0.05 |
| | Ln(K) | **-0.72** | **-1.00** | | | | | |
| | Ln(L) | **1.75** | **3.73** | | | | | |
| | **TFP1** | **0.063** | **4.41** | | | | | |
| | **TFP2** | **-0.080** | **-1.56** | | | | | |
| **33** | Intercept | **-18.74** | **-1.03** | **0.9012** | **40.51** | **0.16** | **1.46** | **0.25** |
| | Ln(K) | 1.51 | 1.66 | | | | | |
| | Ln(L) | 0.59 | 0.95 | | | | | |
| | **TFP1** | **0.038** | **3.05** | | | | | |
| **33** | Intercept | **-32.47** | **-2.28** | 0.9452 | 57.01 | 0.12 | 1.31 | 0.34 |
| | Ln(K) | **2.10** | **2.97** | | | | | |
| | Ln(L) | **0.45** | **0.979** | | | | | |
| | **TFP1** | **0.066** | **5.02** | | | | | |
| | **TFP2** | **-0.418** | **-3.01** | | | | | |
| 34 | Intercept | 1.06 | 0.14 | 0.7038 | 11.29 | 0.05 | 1.72 | -0.08 |
| | Ln(K) | 0.48 | 1.33 | | | | | |
| | Ln(L) | 1.15 | 2.95 | | | | | |
| | **TFP1** | 0.011 | 0.76 | | | | | |
| 34 | Intercept | 4.70 | 0.38 | 0.6760 | 7.78 | 0.05 | 1.60 | -0.01 |
| | Ln(K) | 0.38 | 0.83 | | | | | |
| | Ln(L) | 1.08 | 2.37 | | | | | |
| | **TFP1** | 0.009 | 0.55 | | | | | |
| | **TFP2** | 0.032 | 0.38 | | | | | |

**Table 2(a). Comparative Static Regression for Indian Manufacturing Industries (2-Digit) Over Different Time Spans**

**[Dependent Variable= Ln(Y/L)]**

| Cases | Years | Independent Variables | Coefficients | t-stat | Adju $R^2$ | F value | DW | SC |
|---|---|---|---|---|---|---|---|---|
| Case 1 | 1986-87 & 1990-91 | Intercept | 13.52 | 1.34 | 0.4011 | 6.52(4,29) | 2.23 | 0.00 |
| | | Ln(K/L) | -1.02 | -0.50 | | | | |
| | | $[Ln(K/L)]^2$ | 0.08 | 0.77 | | | | |
| | | D | 1.18 | 0.30 | | | | |
| | | Ln(K/L)x D | -0.17 | -0.46 | | | | |
| | | **SEE** | 0.5850 | | | | | |
| Case 2 | **1986-87 & 1997-98[1]** | **Intercept** | **22.19** | **3.15** | **0.7003** | **19.11(4,27)** | **1.89** | **0.03** |
| | | **Ln(K/L)** | **-2.86** | **-2.01** | | | | |
| | | $\mathbf{[Ln(K/L)]^2}$ | **0.17** | **2.43** | | | | |
| | | **D** | **7.52** | **1.92** | | | | |
| | | **Ln(K/L)x D** | **-0.75** | **-2.14** | | | | |
| | | **SEE** | 0.4047 | | | | | |
| Case 3 | 1990-91 & 1997-98[2] | Intercept | 1.06 | 0.11 | 0.7848 | 29.27(4,27) | 1.45 | 0.25 |
| | | Ln(K/L) | 1.23 | 0.72 | | | | |
| | | $[Ln(K/L)]^2$ | -0.03 | -0.38 | | | | |
| | | D | -1.81 | -0.88 | | | | |
| | | Ln(K/L)x D | 0.12 | 0.72 | | | | |
| | | **SEE** | 0.2523 | | | | | |
| Case 4 | 1990-91 & 1995-96 | Intercept | 0.45 | 0.07 | 0.7835 | 29.04(4,27) | 1.54 | 0.21 |
| | | Ln(K/L) | 1.34 | 1.18 | | | | |
| | | $[Ln(K/L)]^2$ | -0.03 | -0.68 | | | | |
| | | D | -0.77 | -0.55 | | | | |
| | | Ln(K/L)x D | 0.04 | 0.34 | | | | |
| | | **SEE** | 0.2556 | | | | | |

Notes: 1. Metal production & parts (34) have been deleted as outliers for both years. 2. Jute & other vegetable fibre textiles (25) are deleted as outliers for both years.

**Table 2(b). Comparative Static Regression for Japanese Manufacturing Industries (2-Digit) Over Different Time Spans**

**[Dependent Variable= Ln(Y/L)]**

| Cases | Years | Independent Variables | Coefficients | t-stat | Aduj $R^2$ | F value | DW | SC |
|---|---|---|---|---|---|---|---|---|
| Case 1 | 1988 & 1991 | Intercept | 3.82 | 0.49 | 0.7651 | 37.65(4,41) | 1.24 | 0.38 |
| | | Ln(K/L) | 0.99 | 1.05 | | | | |
| | | $[Ln(K/L)]^2$ | -0.02 | -0.51 | | | | |
| | | D | -0.12 | -0.08 | | | | |
| | | Ln(K/L)x D | 0.01 | 0.13 | | | | |
| | | **SEE** | 0.2382 | | | | | |
| Case 2 | **1988 & 2001** | **Intercept** | **-9.05** | **-0.89** | **0.6327** | **20.38(4,41)** | **1.64** | **0.18** |
| | | **Ln(K/L)** | **2.54** | **2.08** | | | | |
| | | **$[Ln(K/L)]^2$** | **-0.06** | **-1.66** | | | | |
| | | D | 1.16 | 0.62 | | | | |
| | | Ln(K/L)x D | -0.07 | -0.62 | | | | |
| | | **SEE** | 0.2968 | | | | | |
| Case 3 | 1991 & 1995 | Intercept | -5021 | -0.49 | 0.6853 | 25.49(4,41) | 1.29 | 0.36 |
| | | Ln(K/L) | 2.07 | 1.63 | | | | |
| | | $[Ln(K/L)]^2$ | -0.05 | -1.22 | | | | |
| | | D | -0.24 | -0.14 | | | | |
| | | Ln(K/L)x D | 0.01 | 0.12 | | | | |
| | | **SEE** | .2852 | | | | | |
| Case 4 | **1991 & 2001** | **Intercept** | **-16.65** | **-1.61** | **0.6441** | **21.36(4,41)** | **1.38** | **0.31** |
| | | **Ln(K/L)** | **3.43** | **2.79** | | | | |
| | | **$[Ln(K/L)]^2$** | **-0.09** | **-2.37** | | | | |
| | | D | 0.99 | 0.55 | | | | |
| | | Ln(K/L)x D | -0.06 | -0.59 | | | | |
| | | **SEE** | 0.2811 | | | | | |
| Case 5 | **1995 & 2001** | **Intercept** | **-23.79** | **-1.79** | **0.5712** | **15.99(4,41)** | **1.00** | **0.37** |
| | | **Ln(K/L)** | **4.24** | **2.72** | | | | |
| | | **$[Ln(K/L)]^2$** | **-0.11** | **-2.40** | | | | |
| | | D | 1.50 | 0.76 | | | | |
| | | Ln(K/L)x D | -0.09 | -0.78 | | | | |
| | | **SEE** | 0.3260 | | | | | |

**Figure 1(a). Upward Shift of the Productivity Locus**

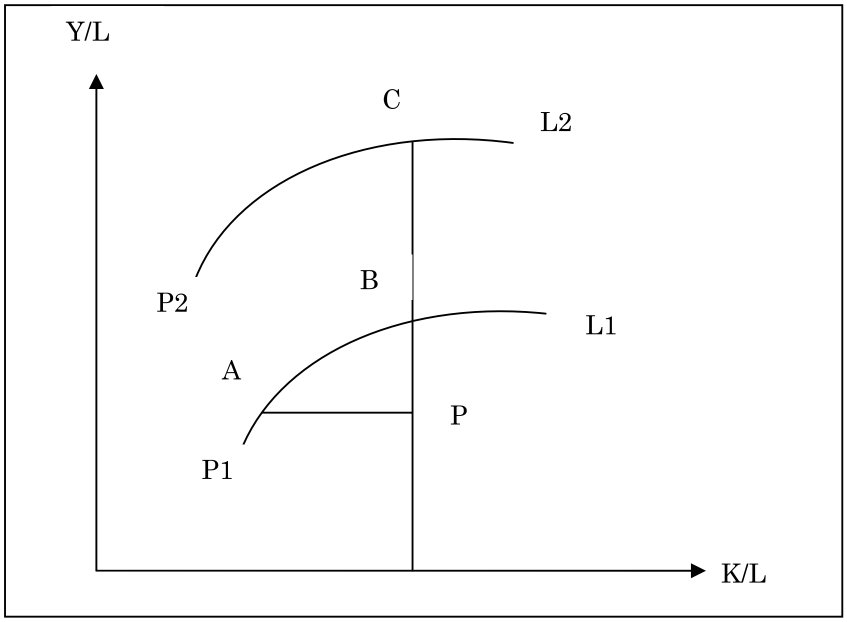


**Figure 1(b). Downward Shift of the Productivity Locus**

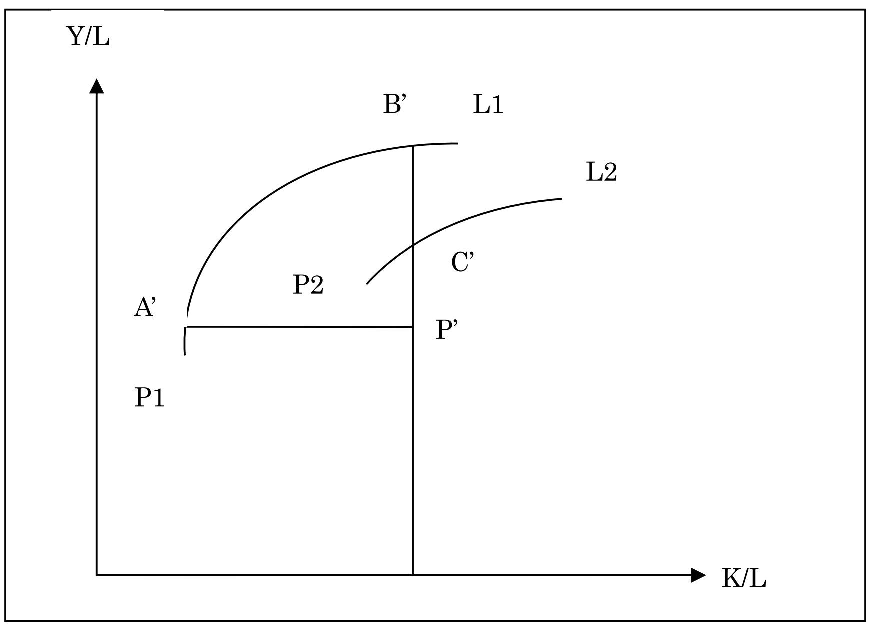

**Figure 2(a). Shift in Productivity Locus in India, 1986-87 & 1997-98**

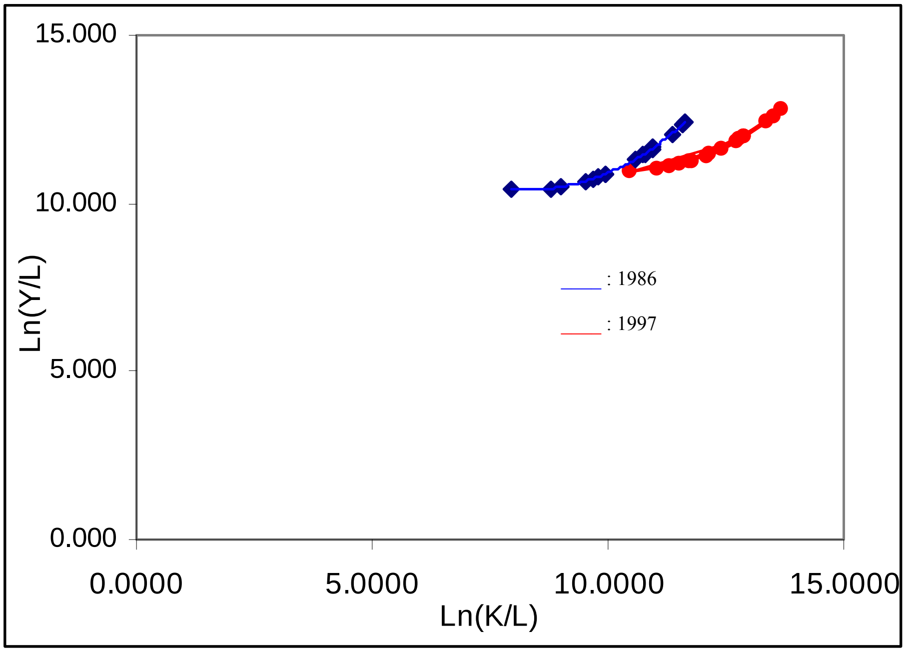


**Figure 2(b). Shift in Productivity Locus in India, 1990-91 & 1997-98**

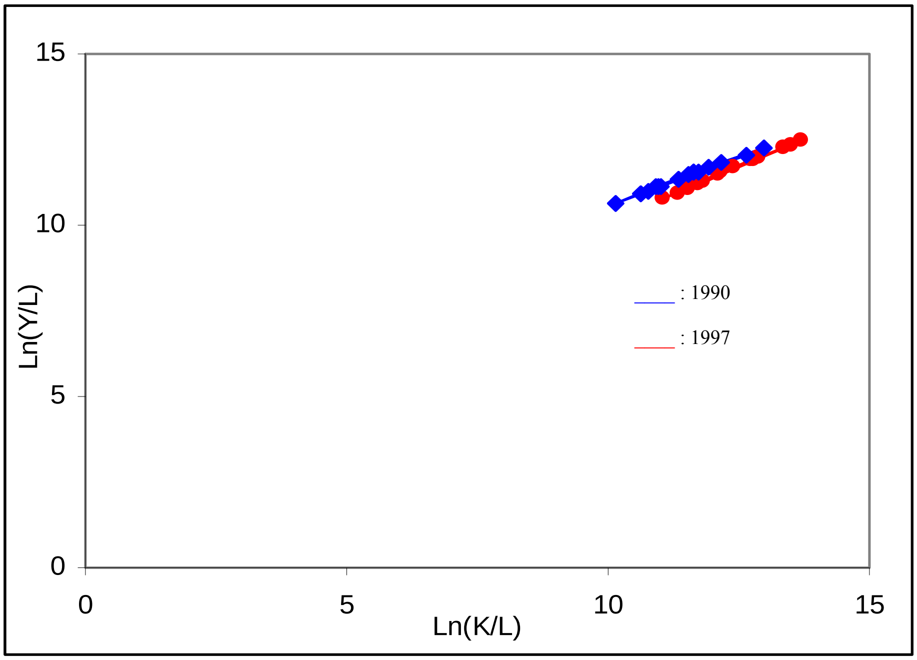

**Figure 3(a). Shift in Productivity Locus in Japan, 1988& 2001**

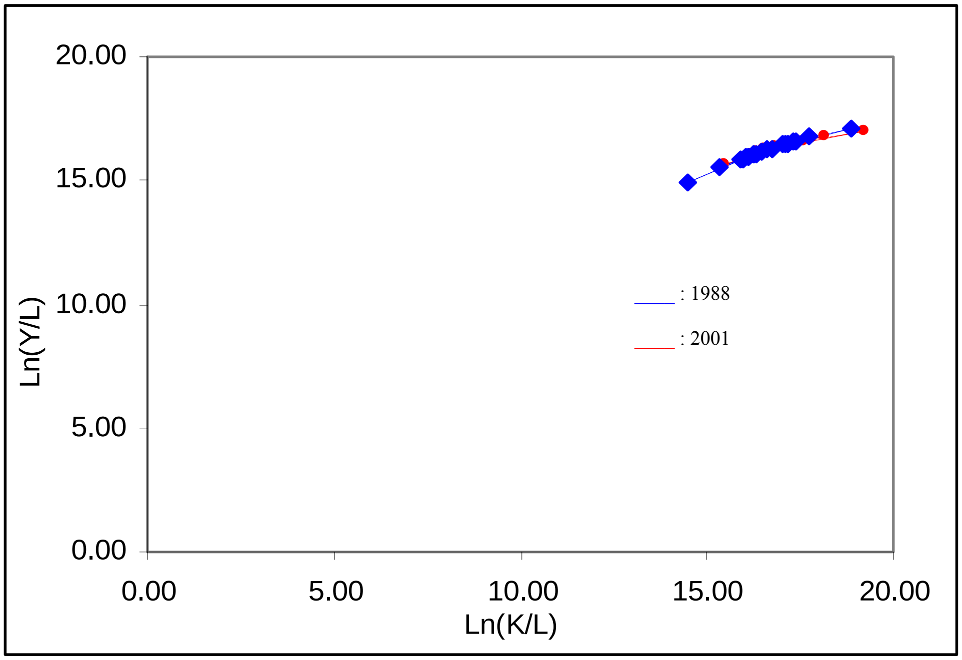


**Figure 3(b). Shift in Productivity Locus in Japan, 1988& 2001**

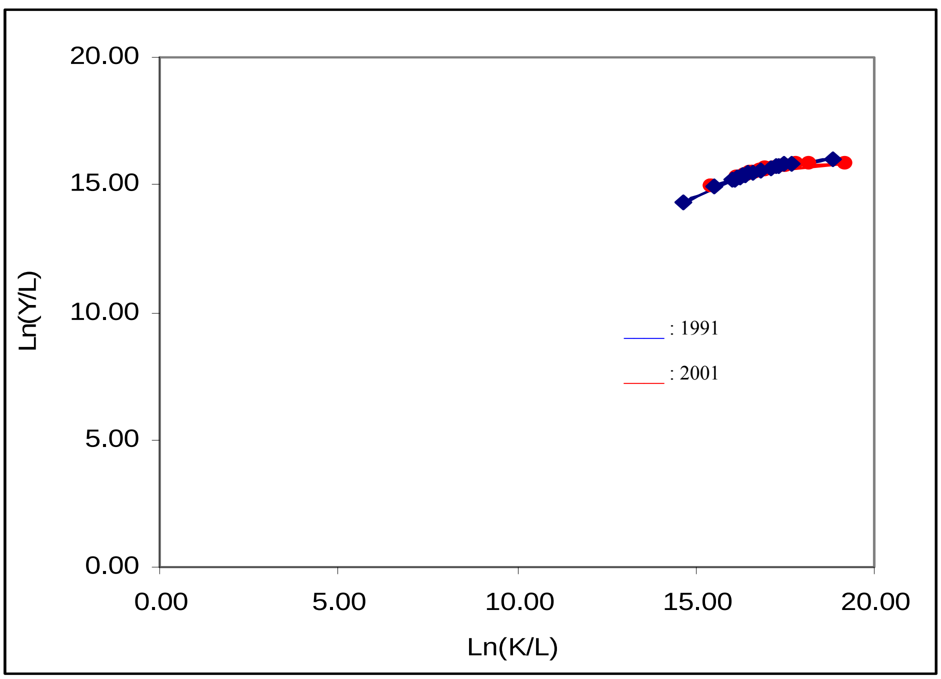

**Figure 3(c). Shift in Productivity Locus in Japan, 1995 & 2001**