Technology, Skill and Productivity: Implications on Employment

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Abstract

The study proposes to focus on rising capital intensity and implications on employment creation. Technology import from developed countries tends to reduce labour demand in general since it is by and large capital intensive. The imported technology also has a strong skill bias with limited opportunities for semi-skilled and unskilled workers. However, the alternate view is that the new technology would create possibilities of product diversification and new products which would throw up new opportunities for employment creation without any commensurate increase in capital. The paper begins by examining the structural shifts that are taking place across countries in favour of the services sector. Then it presents evidence to demonstrate the adverse impact of imported technology on employment. However, the paper indicates the possibility of employment creation through domestic innovation and new technology creation. Finally, it discusses policy issues.

1. Introduction

The basic pre-requisite for improvement in wellbeing levels of those from low income households, is rapid growth in productive employment opportunities. This is an effective way of sharing the benefits of economic growth with the weaker sections of the society, not having enough resources to take part in the growth process directly. It can help create a stable society free from social turmoil and insurgency. A high employment policy is also a way of reducing many other costly government interventions (Bhaduri, 2005). The present study proposes to focus on rising capital intensity and skill intensity associated with new technology and the implications on employment creation. Technology import from developed countries tends to reduce labour demand in general as it is by and large capital intensive. The imported technology also has a strong skill bias with limited opportunities for semi-skilled and unskilled workers. However, the alternate view is that the new technology would create possibilities of product diversification and new products which would throw up new opportunities for employment creation without any commensurate increase in capital. In this context the present paper proposes to focus on the issue of the structural transformation and the excess growth of the tertiary sector (section 2). Section 3 largely deals with the limited labour absorbing capacity of the industrial sector particularly in relation to imported technology. The relationship between innovation and employment is explored in section 4, using the Indian company level data. Finally, section 5 summarises the major findings. The database of the study is drawn from KILM data, ILO Labour Statistics, World Development Indicators (World Bank), UNIDO data and the company level data in India.

2. Structural Shifts and Excess Growth of the Tertiary Sector

In the backdrop of the stylized facts on structural transformation in terms of value added and work force several developing countries have, however, revealed strong deviations. The tertiary sector accounts for a substantial and rising share of output and employment in these economies and this is evident even much before the secondary sector could acquire a reasonable size of at least one-third in terms of value added or work force (Gemmell, 1986). Given the unskilled and semi-skilled nature of the work force pushed out of the agriculture sector it is the high productivity industrial sector which is expected to absorb them productively with the adoption of labour intensive technology. However, if the industrial sector has a limited spread and, further, if it adopts capital intensive technology in an economy confronted with excess supplies of labour, the industry is then less likely to take a lead role in generating productive employment opportunities on a large scale.

Sub-sectors like transport, communication and banking do contribute significantly to the overall economic growth as they constitute the basic physical and financial infrastructure. Especially the role of information technology (IT) and business process outsourcing services (BPOS) in enhancing the economic growth is said to be significant (World Bank 2004). In addition, the new growth theorists indicate that skill intensive activities exert positive externalities on the rest of the economy, and thus concentration of new activities in the tertiary sector with the initiation of IT industry, holds possibilities of raising productivity and growth (Romer, 1990). All this

tends to suggest that services too, in principle, hold the possibility of playing the role of engine of growth. But most of these activities require skilled and educated work force which the surplus labour from the agriculture sector may not meet. On the other hand, the role of industry in generating productive employment opportunities in these countries has been nominal due to the limited spread of the industry and adoption of capital intensive technology imported from labour scarce countries. Skill shortages have expounded the problem as the new technology is believed to be both capital and skill intensive.

Analytical material on innovation, technology, capital intensity and employment: product innovation and process innovation etc.

This section examines the value added and the employment shares of the industry and tertiary sectors and the changes in the sectoral shares over time. The value added share of the tertiary sector dominated (i.e., measured in terms of the ratio of tertiary sector's share to that of industry) that of industry over the period, 1990 to 2003 in most of the sample countries (Fig.1)[1]. In 1990 only Zambia, Venezuela, Botswana, China and Algeria had a lower share of tertiary than industry while Malaysia and Indonesia corresponded to almost equal shares of both the sectors. Similarly in 2003 only China, Algeria, Malaysia, Indonesia and Viet Nam revealed a lower share of tertiary than industry with almost equal weight of both the sectors in Thailand. In all other countries the dominance of the tertiary sector can be observed in a persistent manner.

Over the nineties while several countries[2] including Brazil and Chile experienced a decline or no change in the share of industry, some other countries registered an increase[3]. In the latter group of countries which include Bangladesh and China from Asia, Egypt from Africa and Panama and Peru from Latin America the process of industrialisation in terms of value added does not seem to have ended completely. On the other hand, as far as the tertiary sector is concerned only a handful of countries have either undergone a somewhat decline or witnessed no change in its share in value added over the nineties[4], implying that tertiarisation process is in progress in several countries[5]. However some of these countries, though only a handful in number, do still show signs of improvement in terms of industrialisation. Bangladesh, China, El Salvador, Ghana, Honduras, Kenya, Nicaragua, Nepal and Uganda are the countries where the shares of both industry and tertiary sectors are on the rise (or at least not on the decline), and hence, it may be argued that the structural shift in these countries in favour of the tertiary sector is supported by the industrialisation process as well. Perhaps, this situation results in better outcomes at least in terms of growth

[1] Through out the paper the term industry includes manufacturing as well as construction, mining and utilities. When we refer specifically to the manufacturing sector it includes manufacturing industries only.

[2] Zambia, Brazil, Botswana, Cameroon, Namibia, Ecuador, South Africa, Zimbabwe, Uruguay, Chile, Bolivia, Ethiopia, Mauritius, Mexico, Morocco, Pakistan, Philippines, Tanzania, Argentina, Guatemala, India, Paraguay, Costa Rica, Maldives and Sri Lanka

[3] Kenya, Panama, Peru, Bangladesh, Egypt, El Salvador, Indonesia, Honduras, Nicaragua, Nepal, Algeria, Malaysia, Thailand, Ghana, China, Uganda and Viet Nam

[4] Cameroon, Algeria, Peru, Thailand, Argentina, Egypt, Indonesia, Malaysia, Viet Nam, Maldives and Panama

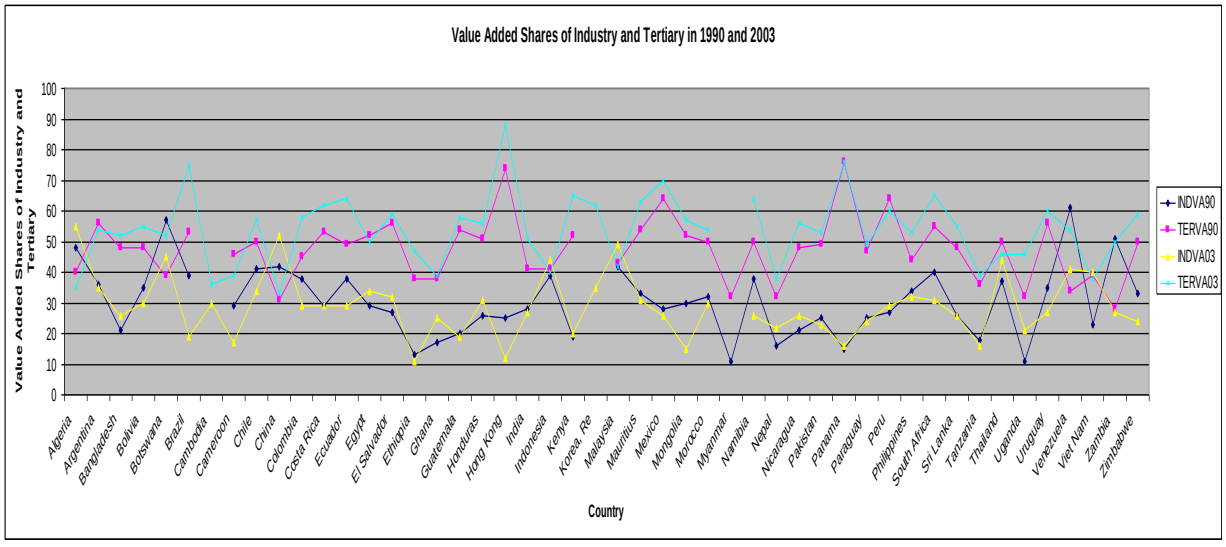
[5] Ghana, China, Paraguay, El Salvador, Tanzania, Bangladesh, Guatemala, Morocco, Pakistan, Uruguay, Honduras, Mongolia, Mexico, Nepal, Bolivia, Chile, Sri Lanka, Nicaragua, Costa Rica, Ethiopia, Mauritius, Philippines, Zimbabwe, India, South Africa, Botswana, Colombia, Kenya, Hong Kong, Namibia, Uganda, Ecuador, Venezuela, Brazil and Zambia.

(see the box below). The rest of the countries, however, largely manifest a rapid expansion of the tertiary sector in terms of value added (see Fig. 2).

To study the structural shift from employment angle the same base and terminal years could not be taken due to the unavailability of data. The base year is not constant for all the countries – depending upon the availability of information it is chosen to be one of the years from the early nineties though there are a few exceptions in this regard. The terminal year corresponds to the first half of the 2000s which again due to unavailability of data could not be kept same for all the countries.

Based on the employment shares it may be noted from Fig. 3 that the industry dominated the tertiary sector - in terms of the ratio between the share of industry and that of tertiary in employment - only in China and Uruguay in the base year (in the early nineties), and only in China in the terminal year (around 2003). In the rest of the countries the dominance of the tertiary sector over the industry is evident in both the years. Over the nineties a very large number of countries registered a sharp decline in the employment share of industry ranging from less than 1 percentage point to more than 21 percentage points[6] which include China. This suggests that in spite of the dominance of the industry in China the declining process, particularly in terms of employment share, is already evident. On the other hand, only a couple of countries recorded an increase of 3 percentage points or more in the employment share of industry over the same period[7] (see Fig. 4). This set includes Ethiopia: hopefully the increasing importance of industry would result in beneficial effects on the poor in Ethiopia where 80 per cent of the population survives on less than a dollar a day (Buckley, 2004). However, with the exception of these few countries the role of industry does not seem to be prominent on the employment front.

Figure 1: Value Added Shares of Industry and Tertiary in 1990 and 2003

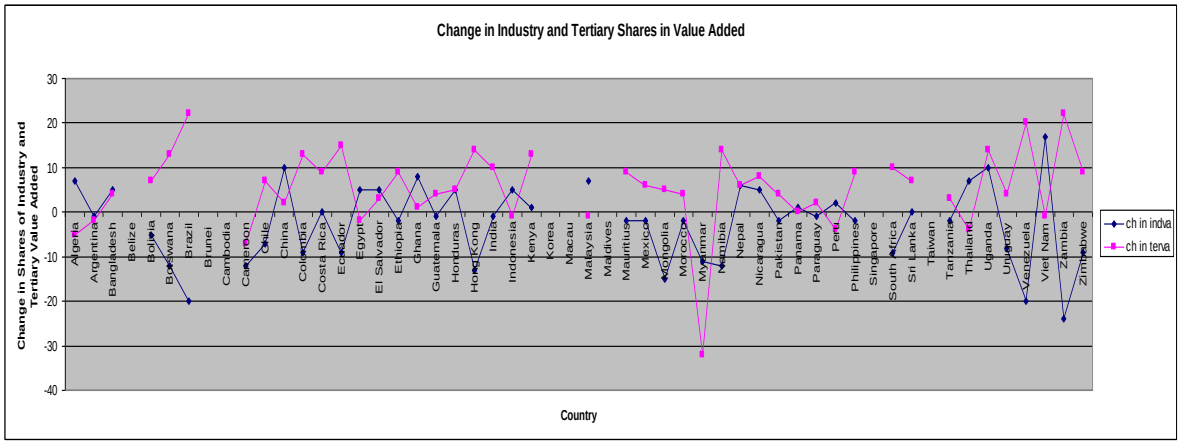


Source: World Development Indicators (World Bank)

[6] Hong Kong, Taiwan, Macau, Colombia, Paraguay, Korea, Argentina, Mauritius, Bolivia, Singapore, Ecuador, El Salvador, Costa Rica, Mongolia, Peru, Venezuela, Namibia, Brunei, Belize, Chile, Mexico, Brazil, China, Tanzania, South Africa, Egypt, Kenya, India, Maldives, Morocco, Algeria and Philippines (in ascending order).

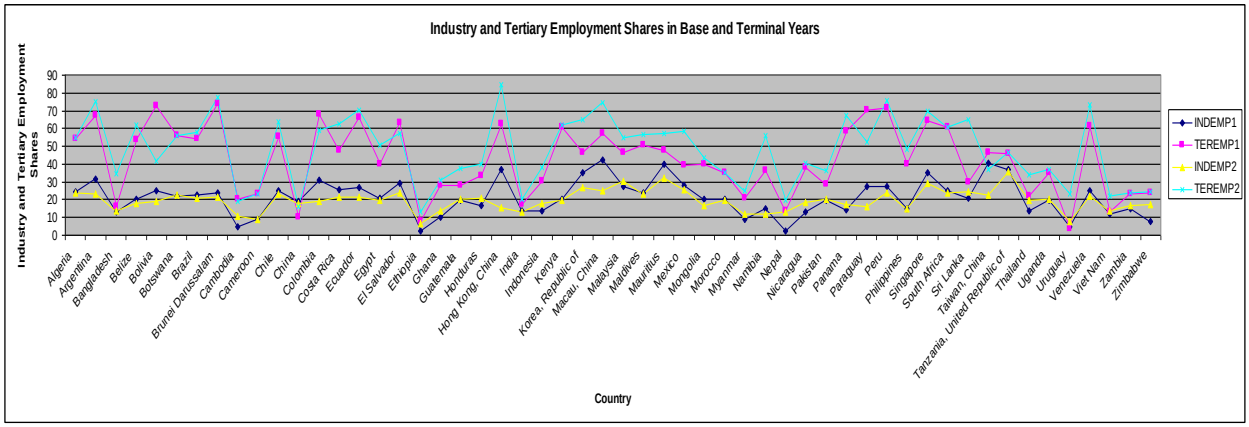
[7] Myanmar, Ghana, Sri Lanka, Honduras, Ethiopia, Indonesia, Nicaragua, Thailand, Cambodia, Zimbabwe and Nepal.

Figure 2: Change in Value Added Shares of Industry and Tertiary



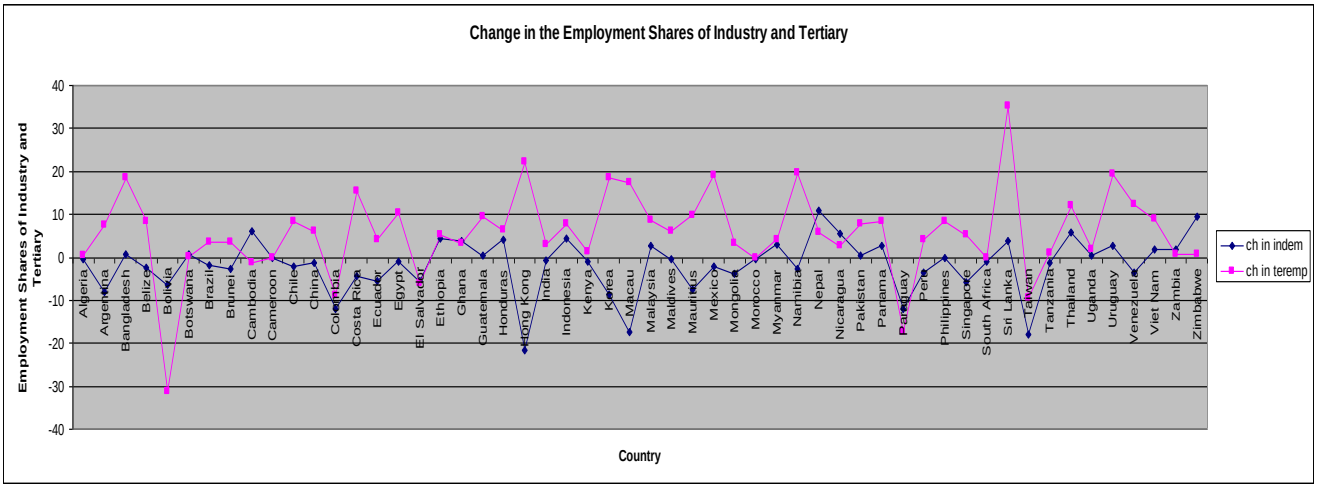
Source: World Development Indicators (World Bank)

Figure 3: Employment Shares of Industry and Tertiary: around1990 and around 2003



Source: See Table A2 in the appendix.

Figure 4: Change in the Employment Shares of Industry and Tertiary



Source: KILM data.

Quite expectedly, only a few countries (Bolivia, Paraguay, Taiwan, Colombia, El Salvador and Cambodia) have undergone a fall in the share of tertiary in total employment while many witnessed an increase of various magnitudes. Interestingly countries which have undergone an increase in the employment share of industry have also seen a rise in their share of tertiary. These countries, though only a few in number, would stand in sharp contrast to the rest as they are experiencing industrialisation and tertiarisation both in terms of employment, whereas the others are witnessing only an increase in the share of the tertiary sector. On the whole, in terms of employment share the inability of the industrial sector to play the role of engine of growth is more prominent than in terms of value added.

The factor analysis has been carried out for two time points on the shares of industry and tertiary sectors in value added and work force and the GDP per capita (in constant prices in terms of US$ for the year 2000) to delineate some of these changes more precisely. The results are also suggestive of an erosion of the industrial base. The factor loadings of both tertiary and industry employment shares took the highest factor loadings for the base year (early nineties) while corresponding to the terminal year (around 2003) the tertiary sector's value added and employment shares are on the top (Table 1). Secondly and quite importantly the variations in industrial value added and employment shares are inversely related, as shown by the signs of the factor loadings corresponding to the terminal year. This was, however, not the case in the base year as both had factor loadings of the same sign. All this would again reconfirm the divergence between movement in the value added share and employment share of the industry, implying the declining labour absorbing capacity of the industrial sector.

Table 1: Results of Factor Analysis

Base Year (Around 1990)		Terminal Year (Around 2003)	
Variables	Factor Loadings corresponding to Factor1	Variables	Factor Loadings corresponding to Factor1
INDEMP1	0.784	INDEMP2	0.168
TEREMP1	0.814	TEREMP2	0.649
PCGDP90	0.307	PCGDP03	0.568
INDVA90	0.288	INDVA03	-0.396
TERVA90	0.259	TERVA03	0.881

Note: (1) INDVA and SERVA are shares of industry and tertiary sectors in value added whereas INDEMP and SEREMP are the shares of industry and tertiary sectors in total employment. PCGDP is per capita GDP. Though 1990 and 2003 are shown to be the base and terminal year respectively there are certain exceptions due to unavailability of data. (2) Only one factor for both the base year and terminal year has been found to be significant, i.e., with Eigen value greater than 1.The number of observations for the base year is 44 and for the terminal year is 48.
Source: Estimated on the basis of the information from KILM Data and World Development Indicator.

On the whole, we note that the structural shift has occurred more in favour of the tertiary sector than the industrial sector across a large number of countries. Some of the studies in the past also attributed the phenomenon of a large percentage of work force being engaged in the tertiary sector to a lack of employment opportunities in manufacturing sector, resulting from the adoption of labour saving technological

change, factor market imperfections and rapid increases in the labour supplies (Meier, 1970). It was also argued that only a small fraction of the tertiary sector employment in the developing countries is a function of the income elasticity of demand for services, and a large majority of it is believed to be a manifestation of excess supplies of labour relative to demand. In other words, every supply of labour is taken to create its own employment in this sector by sharing out a given amount of work (Bhalla, 1970).

It is quite evident from the literature that the tertiary sector comprises highly heterogeneous jobs, which respond differentially to demand and supply factors. Moreover, the degree of responsiveness to a particular set of factors also varies considerable within the tertiary sector depending upon the nature of jobs. Greenfield (1966), for example, by dividing the services into consumer and producer categories, noted that producer services grow as industrial corporations in order to reduce their costs and to use the knowledge of the experts shift some of the tasks previously performed by them, to the producer service firms. Thus in a growing economy, with increasing specialisation and capital accumulation, the demand for producer services is expected to rise. Similarly, with a shift to a predominantly service economy the service organisations in various countries have become large users of information technology, and this has given rise to a large demand for service functions allied to the operation of the computer hardware (Elfring, 1989).

On the other hand, rising female labour participation rate is expected to have a positive effect on tertiary sector employment since women workers prefer tertiary sector jobs, or in other words, this sector is more conducive to absorbing more female labour entering the job market. The relationship between workforce participation rate and tertiary sector employment share has, however, been debated and discussed to a great extent (for details see Thompson and Black, 1975 and Nord, 1989). In particular, as Fuchs (1980) argued, with rising female labour force participation rate the demand for personal services grows, since employed women spend a higher proportion of their income on services which they themselves would have rendered within the household, had they not been employed. Similarly with certain demographic changes, like population ageing, the purchase of specific personal services shows an increasing tendency (Silver 1987). All this tends to suggest that different components of the tertiary sector draw their growth stimuli from different sets of factors, and it would be quite inappropriate to merge all the components in one single category.

Realising the importance of this very fact, Elfring (1989) studied in detail the service sector employment in seven OECD countries under four broad categories: (a) the producer services, (b) the distributive services, (c) the personal services and the (d) social services. Bhattacharya and Mitra (1997) also classified the services sector into four categories – bureaucratic services, distributive services (mostly engaged in the trade and sales), consumer services and producer services. Based on the cross-country analysis their findings suggest that the impact of per capita income on the percentage share of the tertiary sector in total work force is positive, though it tends to stabilise at higher stages of development. At the disaggregate level the results are, however, quite diverse. One important aspect, which needs to be highlighted in this context, is a positive relationship between the level of per capita income and the intensity of use of

services in manufacturing industries[8]. Banga and Goldar (2004) in the Indian context noted that the importance of services as an input to production in the manufacturing sector increased considerably in the nineties compared to the eighties. As the authors pointed out, real value of services used in manufacturing grew at the rate of 0.4 per cent per annum in the 1980s and the growth rate increased sharply to around 16 per cent per annum in the nineties. Economic policy changes in the nineties, particularly the trade reforms, created a condition favourable for increased use of services in manufacturing. Does this mean that services and manufacturing have been complementary to each other? This is, however, a highly debatable issue though the general consensus is that manufacturing holds the key to pro-poor growth while the services sector provides fewer opportunities to the unskilled and semi-skilled workers to be gainfully employed. Sources of livelihood for them within the tertiary sector are not sustainable in the long run as they cannot be provided with decent wages and work conditions.

3. Growth, Employment and Productivity in Industry

Now we turn to the question as to why the industry has not been able to play the role of engine of growth in the developing countries. Our analysis begins with the estimates of employment elasticity and decomposition of value added growth in terms of employment and productivity growth. The issue of negative relationship between productivity growth and employment growth/employment elasticity is examined and possibilities of attaining high growth in both employment and labour productivity are looked into.

It may be important at this point to turn to UNIDO data[9]. The employment elasticity with respect to value added has been estimated from the following function, lnEMP = a+blnVA+clnW, (EMP is employment, VA real value added and W is real wage rate and Ln for logarithm transformation), for the manufacturing sector in each of the countries.

[8] This phenomenon of manufacturing becoming service-oriented is also called splintering of services.

[9] UNIDO data correspond to manufacturing sector. For the manufacturing sector information on employment, value added, wages and salaries and gross fixed capital formation have been compiled by UNIDO. The INDSTAT4 2007 ISIC Rev.3 database reports time series data for currently 113 countries. From this we picked up the South and East Asian, African and Latin American countries for the period starting from 1990 to 2004. The nominal variables are available both in terms of national currency and US dollars. We preferred the later as it would make international comparison easier. The time series of nominal variables reflect (a) the effect of exchange rate fluctuations, (b) price movements in respective countries and (c) the real changes, and we need to eliminate the first two effects. UNIDO used the average period exchange rates as given in the International Financial Statistics to convert the series in dollar terms. This way the effect of changes in the exchange rate are neutralised. As far as the country specific price inflations are concerned we have taken the GDP deflators from the World Development Indicators. Since different countries have different bases we have tried to convert the series of GDP deflators with respect to a common base for all the countries (1990) though this has not been possible for some of the countries which started the series at a later date. The GDP deflators have been used to neutralize the price effect in the series of nominal variables. The deflated wage bill has been divided by the total number of employees to work out the real wage rate. Needless to add that information on all the variables are not reported for each of the years. For some of the countries only on one or two variables and that too for a few years this information is available. Hence, the computation of growth rate of a particular variable does not necessarily reflect the movement from 1990 through 2004.

Employment elasticity estimates (with respect to value added) from the time series data for each country are not highly reliable since the number of observations is often very small. Notwithstanding these difficulties the estimates turn out to be statistically significant not in very many countries: Brazil, Cambodia, Ethiopia, Japan, Korea[10], Madagascar, Malawi, Malaysia, Philippines, Singapore, South Africa and Uruguay. (In a couple of countries like Argentina and Morocco the insignificance is due to multicolinearity.)

However, among the countries where the estimates are significant, only Brazil, Cambodia, Japan and Madagascar show a high employment elasticity of more than 0.7 or near unity. The all-country-pooled data also verifies a moderate employment elasticity of around 0.41 (from Random Effect model). Keeping in view the limitations of the econometric estimations employment elasticity has been estimated simply as a ratio of employment growth to value added growth from UNIDO data which again shows that in a number of countries it has been negative, implying movement in value added and employment in opposite directions. Only in the case of Mongolia, Japan, Vietnam, Cambodia and Korea the employment elasticity turns out to be on the high side (i.e., around 0.7 or more).

With a view to understanding the dynamics of industrialization we need to focus on the relationships between growth patterns in value added, employment and productivity (Ginneken and Hoeven, 1989). Value added can be decomposed in terms of employment and labour productivity:

$VA = (VA/L)*L,$

which implies that over time value added growth equals labour productivity growth and employment growth:

$\ln VA(t) - \ln VA(t-1) = \ln VA/L(t) - \ln VA/L(t-1) + \ln L(t) - \ln L(t-1)$

It may be interesting to identify the countries where the industrial sector has experienced both positive labour productivity growth and employment growth. Quite importantly a sizeable number of countries (around 40 per cent), as per the KILM data, registered a positive growth in both labour productivity and employment. However, the growth rates in both the variables are mostly negligible. In the rest of the countries labour productivity growth and employment growth have moved in the opposite direction. Even from the UNIDO data the inverse relationship between productivity growth and employment elasticity is strongly evident across many countries.

The inverse relationship between labour productivity growth and employment growth (and employment elasticity) becomes distinct particularly when one of the two grows rapidly. Policy planners would advocate for countries with low wages to have higher productivity growth so that the benefits can be transferred partly to the workers. Raising employment growth and employment elasticity can reduce productivity growth, and hence there can be limits to rise in employment elasticity. On the other hand, sluggish productivity growth and employment growth both is not a desirable outcome even if it may imply higher employment elasticity. Only when value added growth is stepped up by total factor productivity growth (i.e., TFP driven growth), employment growth can be faster and both employment elasticity as well as

[10] Only Korea shows a wrong sign.

productivity growth can be raised[11]. Even if employment elasticity declines employment growth can still be greater[12].

The other mechanism by which both productivity and employment growth can be stepped up is by reducing under-capacity-utilization. Thus we may conclude that with TFP-driven-growth and with increased utilisation of capacity it is possible to experience both rise in labour productivity growth and employment growth provided the technology is labour intensive in nature. This may sound paradoxical since technological progress is usually assumed to be capital intensive, but analytically it is possible to demonstrate that technological progress can also take place with labour intensive technology (Chowdhury and Tatjoeddin, unpublished). Empirically also it is difficult to identify countries which have experienced both positive and high growth rates in labour productivity and employment (except a few countries like Cambodia, Ecuador, Indonesia, Morocco and Vietnam where both the growth rates turn out to be positive though both are not high). This is mainly because countries have pursued accumulation of capital largely through imports. Hence, for most of the developing countries the issue is to pursue technological progress with labour intensive technology so that industrial growth can result in both higher employment growth and labour productivity growth. Instead of putting too much emphasis on the discussion on employment elasticity attempts need to be made to explore possibilities of identifying mechanisms that can support investment towards technological advancement suitable to the existing labour market therein.

Import of Technology and Employment

It is often argued that developing countries import technology from developed countries, resulting in a mismatch between the technological requirements of the former and the available technology (for instance, Pack and Todaro 1969). Technology innovated in the developed world is mainly labour-saving and skill-intensive as it has to suit the situation prevailing in the developed economies. On the other hand, developing countries are mainly labour surplus and skill scarce economies and hence, the objective of employment growth along with economic growth gets defeated when technology is largely imported from abroad. In this section we propose to examine whether import of technology affects the utilization of labor.

As Azeez (2006) points out distinctly, a new technology gets embodied in capital goods, and therefore, import of capital goods is often considered as import of technology. Once imported capital good is put into operation, the technological progress realized in the country of origin will be incorporated into the production process (UNIDO, 2005). Hence, it is still cheaper for a latecomer to buy the technology already invented by others than to re-invent the wheel though it is widely noted that international technology does not come cheap (UNIDO, 2005). Hence, the debate relating to the nature of technology gets shifted to the import of capital goods. The overall effect of the import of technology or capital on developing economies needs to be assessed, based at least on its effect on productivity enhancement and labor absorption.

[11] Situation 1: value added growth : 6 per cent, employment growth, 5 per cent, and labour productivity growth 1 per cent and employment elasticity 0.83. Situation 2: value added growth : 8.1 per cent, employment growth, 7 per cent, and labour productivity growth 1.1 per cent and employment elasticity is 0.86.

[12] Situation 3 : value added growth : 10 per cent, employment growth, 7 per cent, and labour productivity growth 3 per cent and employment elasticity 0.7.

Though the import of technology from developed countries may be expected to enhance the productivity in developing countries, there are plausible doubts about this effect. Chakravarty (1987) noted that with imports of capital goods on a significant scale, domestic costs of production are unlikely to come down if the imports and domestic production involve substitutability. Developing countries might be importing expensive capital goods that could be produced in their own countries. Chandrasekhar (1992) argued further that in the Indian context imports of capital goods have acted as substitutes for domestic production of capital goods, imposing a social cost in the form of unutilized capacity. And this made the domestic firms operate at high unit cost of production. Hasan (2002) in this respect noted that productivity-enhancing effects of domestic capital goods appear to owe more to the disembodied technologies imported by producers of domestic capital goods than the R& D they conduct. However, Hasan (2003), Wood (1997) and Robbins (1997) did not find any noticeable positive effect of trade reforms on employment though Ghose (2000) noted that the employment effects of trade in manufactures with industrialized countries are potentially positive and large in developing countries.

Further, imported technology may require more skilled workers than unskilled workers while in developing countries the latter category of workers are usually available abundantly. Acemoglu and Zilibotti (2001) argue that technology in developed countries tends to be skill intensive and is inappropriate for developing countries. Thus the potential productivity of imported technology cannot be realized in developing countries.

In the backdrop of these views and findings we examine the nature and quantum of import of technology from abroad, and assess its impact on employment generation and technical efficiency in the technology-importing countries. Imports of goods and services relative to GDP show considerable variations across countries. Within the category of merchandise imports manufactures constitute a significant component. Merchandise imports are the cost, insurance and freight (c.i.f.) value of goods purchased from the rest of the world. Manufactures correspond to chemicals, basic manufactures, machinery and transport equipment, and miscellaneous manufactured goods.

The proportion of manufactures to total merchandise imports varies considerably across countries. Only a handful of countries such as Gambia, Korea (Re), India, Japan, Nepal and Egypt, reported the percentage of manufactures below 60 per cent. The rest reveal a much higher figure. From the total imports of merchandise it is difficult to delineate the component that can be attributed to import of technology. Hence, to test our hypothesis that higher imports of foreign technology reduces labour absorption, we have taken the percentage of manufactures in total merchandise imports (MFGIM) as a broad proxy for import of technology. It may be, however, noted that manufactures imports include finished products other than capital and intermediary inputs. Since further dis-aggregation was not possible from the available data this rough proxy had to be followed. We, therefore, need to interpret the results carefully. It is quite possible that import of finished products included in the imports of manufactures can reduce domestic production if the latter cannot compete with imports, and this in turn may reduce employment in the industrial sector of the importing country. In order to overcome this problem we have redefined the concept of labour absorption instead of merely taking in terms of employment growth. The quantum of labour absorption is measured as the labour engaged per unit of real value added (i.e., the ratio of labour to real value added, LPERVA). The other variables,

which have been controlled for, are the real wage rate per employee (REWAGR) and the real per capita gross domestic product (GDPPC). While the figures on labour per value added and real wage rate have been derived from the UNIDO data with the help of GDP deflator from the World Development Indicators, the real GDP per capita (constant prices, in terms of US$ for the year 2000) and the percentage of manufactures to total merchandise imports have been taken from the World Development Indicators. The data set constitutes the time-series-cross-section-pooled information for 36 countries over the period 1990 to 2004. However, as mentioned above, the missing observations are too many in number.

In addition to the classical regression (OLS), the equation has been estimated by the standard techniques for panel data analysis: Fixed Effect model and Random Effect model. Between the two, Hausman test does not reject the null hypothesis in favour of the random effect model though the Lagrange Multiplier test does not reject the OLS estimates. The results presented in Table 16 show distinctly that in all the three models the percentage of manufactures in total merchandise imports remains statistically significant with a negative sign. This tends to support our hypothesis that with higher imports of technology, labour per unit value of real value added declines. The other two variables do not turn out to be significant in the FE or RE model though in the classical regression model they are significant with the right signs. With a rise in real wage rate labour demand tends to shrink and with a rise in per capita GDP, implying growth, employment shoots up.

Table 2: Panel Data Estimation for Thirty-Six Countries

Dependent Variable: LPERVA

Variable	OLS	FE	RE
REWAGR	-3.09e-07 (-3.80)*	1.09e-08 (0.14)	-2.56e-08 (-0.35)
GDPPC	1.91e-07 (2.84)*	-2.29e-08 (-0.20)	-3.87e-08 (-0.49)
MFGIM	-0.00003 (-1.99)*	-0.000064 (-2.75)*	-0.00005 (-2.51)*
Intercept	0.0037 (3.11)*	0.005 (3.34)*	0.005 (3.44)*
R 2	0.13 (F= 8.95)*	0.03	0.06

Note: Hausman statistic = 3.41 suggesting that between FE and RE the latter is to be chosen. * represents significance at 5 per cent level. N= 187.

Source: Based on data from UNIDO and World Development Indicators for 36 South and East Asian, Latin American and African countries.

This may be taken to interpret that mere availability of technology does not mean better performance. If the available labour resource is poorly skilled it is natural to witness poor performance in terms of technical efficiency. Hence, skill up-gradation and training and research and development for technological advancement that suits the labour market conditions of these economies are two important policy conclusions that follow from our analysis.

Performance (Technical Efficiency) and Import of Technology

Having substantiated with evidence in favour of a possible negative association between the import of technology and labour per unit of real value added we pursue this point a little more in terms of technical efficiency. As per this strand of argument, the availability of technology from abroad does not necessarily mean that the importing countries have the requisite resources and the manpower to operate the technology. In our review of certain studies in this respect we have already pointed out that there is a growing body of literature suggesting low level of skill-base of the work force in the developing countries while the technology imported from abroad is highly skill-intensive in nature. In this part of the paper based on cross-sectional data this particular point is pursued empirically. The open economy assumption with free flow of technology across countries is a requirement. In other words, in a globalizing world we assume that invention, transfer and dissemination of technology take place without any time lag, as a result of which countries at different levels of development are able to access the same technology.

The adverse effects of imported technology on performance are assessed in two steps. First, using the concept of frontier production function, we estimate technical efficiency for the aggregate manufacturing sector which is taken to be the performance indicator. In the second step, we examine the association between the technical efficiency of the aggregate manufacturing sector on the one hand and on the other, the percentage of manufactures in total merchandise imports and per capita income.

Based on the cross sectional data for 30 countries the value added frontier function (lnVA) has been estimated by Maximum Likelihood Estimate (Table 3). Since no other information is available on capital stock, real gross fixed capital formation (GFCF) has been taken as a proxy. Though elasticity of value added with respect to labour and capital both are positive implying positive marginal productivity for both the factors of production, the coefficient of labour (lnEMP) does not turn out to be significant.

Based on the frontier function framework technical efficiency index (TECHEFF) has been estimated by characterizing the most efficient firm as 100. This index has been regressed on the import and growth specific variable, i.e., GDP per capita (GDPPC). Results suggest that countries with higher import of manufactures to total merchandise imports (MFGIM) are associated with lower technical efficiency levels (Table 3). This may be taken to interpret that mere availability of technology does not mean better performance. If the available labour resource is poorly skilled, it is natural to witness poor performance in terms of technical efficiency. Hence, skill up-gradation and training and research and development for technological advancement that suits the labour market conditions of these economies, are the two important policy conclusions of this study.

Table 3: Value Added Function and Technical Efficiency Equation

Variable	Dep Var. lnVA (MLE Estimates)	Dep. Var. TECHEFF (OLS Estimates)
LnEMP	0.01 (0.03)	
LnGFCF	0.89 (5.23)*	
MFGIM		-0.98 (-2.12)*
GDPPC		-0.0007 (-1.21)
Intercept	4.69 (3.78)*	86.31 (2.64)*
N	30	26
Adj R^2		0.13

Note: ln is logarithmic transformation. * represents significant at 5 per cent level.
Source: Based on data from UNIDO and World Development Indicators.

In order to pursue further the point of skill-mismatch we have followed-up the analysis with another exercise. World Development Indicators report for various countries the percentage of manager indicating labour skill as a major business constraint (LABSKILL)[13]. The higher is the percentage figure, the higher is the possibility that the skill factor affects employment adversely. We have tried to relate the skill specific responses to the rate of growth of employment (ROGEMFG) in the manufacturing sector from UNIDO data. Interestingly the skill factor is seen to affect employment growth in the manufacturing sector negatively (Table 4). In other words, higher is the percentage of managers who feel skill has been affecting business adversely, the lower is the rate of growth of employment in the manufacturing sector. All this is indicative of poor skill base of the work force in the developing countries which reduces the pace of labour absorption as labour demand in the face of imported technology is possibly rising only for the high skilled variety.

Table 4: Employment and Skill: Regression Results

Variable	Dep. Var. ROGEMFG
LABSKILL	-0.47 (-1.93)*
INTER	14.30 (2.60)**
Adj. R^2	0.11
N	22

Note: N stands for the number of observations. ** and * represent significance at 5 and 10 per cent levels respectively.
Source: Based on data from UNIDO and World Development Indicators.

[13] Berg and Cazes (2007) however point out the serious conceptual and methodological problems associated with the World Bank's Employing Workers Index of the Doing Business indicators and risks of formulating policies on the basis of these indicators.

Those who support labour market deregulation believe that the cost of labour is too high. In the context of globalisation firms need to become more competitive by cutting cost and high labour cost is thought to be one of the major sources of inefficiency. Labour rules and strong unions are believed to push the wage rate artificially much above the market clearing wage rate which in turn suppresses employment. Hence, labour market deregulation is expected to reverse the attitude of the employers against expanding employment since it empowers them to hire and fire labour as per requirement and offer wages which allow product prices to remain competitive.

Based on the UNIDO data the average labour cost (real wage rate multiplied by total employment) as a percentage of real value added over the period 1990 through 2004 has been estimated for the manufacturing sector. Table 5 shows that of the 36 countries for which this ratio could be calculated only eight reported a figure of more than 35 per cent. To begin with, high cost of labour argument, therefore, does not seem to have a strong basis to build a case for labour market deregulation.

Table 5: Average Labour Cost as a Percentage of Real Value Added in Manufacturing (over 1990 through 2004)

Country	Labour Cost: below 20 per cent	Country	Labour Cost: 20 to 30 per cent	Country	Labour Cost: more than 30 per cent
Ecuador	12.49	Bangladesh	22.01	Vietnam	30.68
Sudan	13.34	Rwanda	23.08	Mongolia	30.71
Colombia	14.39	Cambodia	23.34	Uruguay	30.80
Bolivia	14.63	Korea, Re	23.71	Gambia	31.16
Philippines	17.11	Zimbabwe	23.73	Singapore	34.06
Indonesia	17.37	Brazil	24.34	Argentina	35.01
Ghana	17.87	Malaysia	24.58	Senegal	35.19
Peru	18.37	India	24.73	Egypt	35.42
Eritrea	18.65	Madagascar	25.11	Panama	36.70
Nepal	18.75	Botswana	25.96	Morocco	39.93
Mexico	18.79	Japan	27.73	South Africa	41.11
Ethiopia	19.10	Thailand	29.03	Mauritius	44.40
		Malawi	29.24	Macau, China	60.72

Source: Based on UNIDO Data.

4. **Innovation and employment: All-India Study**

In a number of studies a serious concern has been expressed with regard to the negative relationship between innovation and new technology on the one hand and employment on the other (Ugur and Mitra, 2017). One may pose the question in relation to product and process innovation. The interaction between economic integration, product and process innovation, and relative skill demand is an important aspect, which Braun (2008) analyses in a model of international oligopoly. Lowering of trade barriers increases the degree of foreign competition which may have effects on the incentives of firms to undertake R&D investment and also the firms' demand for skilled relative to unskilled workers. Increased competition following economic integration induces firms to bring down production costs by investing more

aggressively in process R&D. At the same time, competitors expand their investments in product innovation in order to reduce the substitutability of their products. However, all this would require highly skilled human labour which can initiate newer ways of introducing cost efficient production processes and bring down the product differentials between the imported goods and the domestically produced goods. On the whole, economic integration and innovation are inter-linked resulting in an increase in the relative demand for skilled workers[14] and not the unskilled or semi-skilled variety of labour force which is in excess supply in most of the developing countries. Innovation and skill intensity usually go together – hence, even if innovation is not always labour displacing it benefits only those who are relatively in short supply. This tends to indicate that wage inequality is likely to increase in the process of innovation and increased trade.

On the empirical front Berman and Machin (2004) showed the skill-bias of technological change especially in middle-income countries. Pianta (2005) emphasizes that innovation-based growth and job creation may operate in drastically different ways during different phases of the cycle, implying that the employment dynamics are not affected by the same factors and in the same ways during the upswings and the downswings. Piva (2003) presents a critical comparison of the positive implications of technology transfers (such as positive spillovers, technological catching-up, growing complementarities with domestic firms) with the negative ones (displacement of workers, negative welfare implications, competitive effects with domestic firms). Also, the author considers the nature of transferred technologies (labour-saving and/or skill-bias, embodied or not embodied in capital), together with the different institutional 'absorptive capacities' and sectoral specializations of both middle-income and low-income developing countries.

Lee and Vivarelli (2006) suggest that import of capital goods may imply an increase in inequality via skill-biased technological change. Imports of capital goods, - embodying technological innovations - are important because of the role they play in contributing to capital upgrading and more generally to the economic growth of the developing countries. In fact, even without necessarily assuming that developed countries transfer their "best" technologies, transferred technologies are relatively skill-intensive, i.e. more skill-intensive than those in use domestically before trade and FDI liberalization. Thus openness – via technology – should imply a counter-effect to the SS theorem prediction, namely an increase in the demand for skilled labour, an increase in wage dispersion and so an increase in income inequality.

Castellani and Zanfei (2006) present an in-depth theoretical and empirical analysis of the key issues underpinning the relationship between innovation and multinational companies. The authors argue that neither every foreign firm is a good source of externality nor every domestic firm is equally well placed to benefit from multinationals. Spillovers from multinationals differ according to the technological profiles, embedded-ness and linkage creation of both foreign and domestic firms. Hasan (2002) presented evidence from panel data on Indian manufacturing firms in favour of a significant effect of imported technology on productivity. In general the empirical literature on R&D, using cross-sectional data, reports strong evidence in

[14] Vivarelli (2011) argues that innovation has a strong skill-bias.

favour of its positive effect on productivity while the time series estimates are less conclusive (Crespi and Pianta, 2006). Using data on 33 Indian manufacturing industries in India for the period, 1992 through 2001, Pandit and Siddharthan (2006) further showed that technology imports, through joint ventures and MNE participation, influence employment positively. They noted that employment growth, production of differentiated products, skill intensity of the work force and technological up-gradation go hand in hand.

The "compensation theory" as Vivarelli (2013) points out, argues that technological unemployment is a temporary phenomenon. The labour saving effects of technology can be offset through:

(1) additional employment in the capital goods sector where new machines are being produced,
(2) decreases in prices resulting from lower production costs on account of technological innovations,
(3) new investments made using extra profits due to technological change,
(4) decreases in wages resulting from price adjustment mechanisms and leading to higher levels of employment,
(5) increases in income resulting from redistribution of gains from innovation, and
(6) new products created using new technologies (Vivarelli, 2013).

We have used the firm level data in the Indian manufacturing sector, compiled by ACEEQUITY for the period 1998 through 2010. ACEEQUITY is one of the agencies which collect from the firms' annual reports information on various aspects such as sales, assets, wages and salaries, exports and imports and expenditure on R&D. We have extracted information for eleven groups of industries. The number of firms in many of these industries is sizeable – in fact, most of the large firms are included in the study. However, the panel is not balanced as the information on all the variables for a given firm is not available for all the years.

In several studies employment is taken to be a function of value added and wage rate to estimate the growth and wage elasticity of employment. Following the same logic we may regress log of employment on log of real sales, real wage rate (derived by deflating the nominal figures by the consumer price index for industrial workers), and in addition real RND (deflated by the price index for machinery). Since R&D/Sales ratio has a highly limited variation across companies and over time, log of R&D may be considered to be more suitable.

In this specification (Table 6), log R&D turns out to be significant with a positive effect in a number of industries (seven) and the elasticity of employment with respect to R&D is seen to be highest in Consumer Durables (around 0.3). In two other industries (Leather and Pharmaceutical) it is again a little above 0.1. In Electric Equipment, Electronics Component and Household and Personal Products also the estimate is closer to 0.1.

Table 6: Partial Elasticity of Employment with respect to Sales, Wages and R&D
Dependent variable- LnEmployment

Industry	Model	lnSales	LnR&D	lnWage rate	Constant	R^2 /Adj R^2	N
Consumer Durables-Domestic Appliances	RE	0.784** (15.03)	0.051** (2.02)	-0.470 (-1.40)	-2.36** (-2.78)	0.89	78
Consumer Durables-Electronics	OLS	0.498** (8.74)	0.297** (8.48)	-0.325 (-0.41)	-0.448 (-0.35)	0.95	33
Chemical	FE	0.497** (14.99)	0.015 (0.74)	-0.745** (-8.59)	1.180** (4.13)	0.71	586
Electric Equipment	FE	0.484** (10.34)	0.070** (3.98)	-0.821** (-4.61)	1.55** (4.49)	0.85	225
Electronics Component	RE	0.581** (14.03)	0.066** (2.38)	-1.348** (-6.79)	1.358** (2.69)	0.92	101
Engineering	FE	0.477** (11.79)	0.023 (0.96)	-1.051** (-16.56)	2.712** (7.37)	0.77	186
Engineering Construction	RE	0.825** (10.30)	0.007 (0.28)	-1.012** (-2.34)	-1.760** (-2.29)	0.73	83
Engineering – Industrial Equipments	RE	0.732** (17.16)	0.017 (0.67)	-0.861** (-8.28)	-0.559 (-1.40)	0.84	98
Household & Personal Products	RE	0.745** (12.07)	0.065** (2.62)	-0.904** (-5.30)	-0.476 (-0.70)	0.95	61
Leather	RE	0.802** (6.96)	0.153** (2.19)	0.124 (0.17)	-3.142** (-2.45)	0.67	54
Pharmaceuti-cals & Drugs	FE	0.443** (18.30)	0.117** (7.67)	0.007 (0.07)	0.811** (3.55)	0.82	1194

Note: Figure in parenthesis are t- values for FE model and OLS and z-value for RE model. ** and * denote 5% and 10% level of significance, respectively. FE denotes fixed effect model: RE denotes random effect model: OLS denotes ordinary least square. Adj. R^2 is calculated only for OLS.

5. Conclusion

This study in the context of developing countries notes the dominance of the services sector over the industrial sector. Also, over time a significant increase seems to have taken place in the share of the services sector in terms of value added as well as employment. The occurrence of industrialization and tertiarisation both is evident only in a few countries. The dwindling share of industry and the phenomenon of deindustrialization, particularly in terms of occupational structure, are indicative of the shrinking labour absorbing capacity of the industrial sector. Sources of livelihood for the unskilled and semi-skilled workers within the services sector are not sustainable in the long run as these activities cannot provide decent wages and living conditions to the workers.

We examined the possible effect of the imported technology on the ratio of labor to unit value of output (real value added), after controlling for real wage rate and GDP per capita. Findings show a negative relationship between the two: as the ratio of

manufactures to total merchandise imports increases, the ratio of labor to value added tends to decline, suggesting that higher dependence on the import of foreign capital leads to a sluggish absorption of labor in the manufacturing sector. It may, however, be noted that manufactures imports include finished products other than capital and intermediary inputs, and, therefore, the results need to be interpreted carefully.

On the whole, a mere increase in the capital-labour ratio is not adequate to reflect technological progress and with liberalization if there is a growing tendency to import capital in the name of technological progress it is unlikely to generate employment. All this raises labour productivity and creates the illusion of technological progress though actually it could be the result of capital deepening process. Without enhancing the knowledge relating to the mechanisms of exploiting the new technology acquired from abroad, a mere import in technology would mean rising unutilized capacity.

This is evident from the finding on technical efficiency though it is based only on cross-sectional data. Technical efficiency, which is indeed a performance indicator, has been estimated pertaining to the aggregate manufacturing sector using the concept of frontier function framework. And in the second stage its association with the ratio of imports of manufactures to total merchandise imports has been examined. The results tend to suggest that import of technology has an adverse effect on the technical efficiency. In other words, higher the import of technology, greater is the distance between the actual production and the maximum attainable level of output. These findings imply that the imported technology is not being utilized optimally which could be due to poor skill base of the available human capital. Investment in human capital in terms of skill formation, up-gradation and training on the one hand and technological advancement to suit the internal labour market conditions, rather than merely relying on the import of technology from abroad, are the two important policy conclusions for reviving the role of industry as the engine of pro-poor growth. With TFP-driven-growth based on technological progress that is labour intensive in nature and with improvement in capacity utilization both labour productivity and employment growth can be raised simultaneously. The other important strategy for raising productivity and employment lies in choosing a suitable mix of industries and sectors though investments in social and economic infrastructure are basic prerequisites for enhancing productivity. A profound employment policy with a special focus on employment generation in the industrial sector and on safety-nets is indeed crucial to growth with poverty reduction. The lack of skill has indeed shown a negative impact on employment. All this would tend to reinforce the policy focus on strategies for skill formation.

On the whole, the development experience of the developing countries does not seem to be resulting in pro-poor growth. From the policy point of view the revival of the industrial sector for productive employment generation is indeed crucial to economic progress with poverty reduction. The company level data from India further confirms that innovation expenditure has a positive effect on employment in a number of industries. Processing of by-products and efforts pursued to bring in an improvement in product quality and efficiency, are some of the striking features of R&D expenditure, which may be resulting in employment gains. Even when capital intensive technology is adopted by the firms, R&D expenditure has the potentiality to generate employment as it means additional activities without involving additional capital. From this point of view the study has important policy implications: more schemes need to be introduced which can provide incentives to encourage R&D

expenditure. Effective supervision can also channelize R&D expenditure towards actual innovation of technology that is appropriate for labour surplus countries.

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