Paradigm Changes in Technology and Employment

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1 Introduction

Whenever paradigm changes took place in technology, issues relating to employment or the fear of technological unemployment assumed importance. As Schumpeter (1942) emphasized, unlike trajectory changes in technology that are incremental, paradigm changes resulted in new goods and processes that didn't compete with the existing goods at the margin but resulted in the destruction of the existing goods and processes. He termed them the processes of 'creative destruction'. The neo-Schumpeterians have been terming the trajectory changes as 'creative accumulation' (Archibugi et al. 2013). To illustrate the concepts, Schumpeter gave examples of the introduction of railways resulting in the destruction of stagecoaches, and the introduction of steam power and its use resulting in the sharp decline of artisans. However, in these cases despite the destruction of some industries and sectors the overall employment didn't decline. The technological revolution contributed to a sharp decline in the prices of the goods, in particular, textiles, clothing and consumer durables that were earlier produced by artisans. The sharp decline in prices made these goods to come within the reach of the middle and lower middle-income groups. Earlier the markets for these goods were provided mainly by the rich. The rapid expansion of the markets and the huge entry of new consumers more than compensated for the loss of jobs in the affected sectors. Employment in the economy as a whole increased.

In more recent times, when banking, travel and insurance were computerized, there were protests from trade unions against computerization. The unions feared that it would result in the loss of jobs. In the banks the number of workers per account

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did decline but the overall employment did not decline, in fact it increased. The banking services before computerization were not comparable to the services in the post computerization era. The demand for the new banking services increased rapidly resulting in more employment. Similar is the case with travel and insurance sectors. It is important to keep these in mind while discussing the current technological revolution and its impact on employment.

2 Gainers and Victims

Examples of paradigm changes include Genomics and Digital technologies including artificial intelligence, robotics and cloud computing. They are likely to affect all sectors—health, medicine, agriculture, manufacturing, trade and financial intermediation. They will affect all nations. This is one of the reasons for not terming the current revolution as industrial revolution as it was the case earlier. With regard to employment, paradigm changes will benefit some and harm others. The objective of this section is to identify to the extent possible the gainers and victims. All technological revolutions bring with it beneficiaries and victims. The victims of the first industrial revolution, namely, the steam revolution were the artisans, weavers, garment manufactures and stagecoach operators. Due to the expansion of the markets and increased demand for the new products, the overall employment in the economy did not decline. Autor (2015) partly attributes this to not considering output elasticity of demand along with income elasticity of demand. However, he also admits to some sections of population becoming victims and unemployed. Nevertheless, there will also be gainers. He argues that computers cannot perform abstract tasks and professionals and persons performing personal services will not be adversely affected. Furthermore, currently collaborative efforts are assuming importance and they need human interactions and cannot be handled by machines. His evidence suggests that technology has boosted the output of the professionals and the demand for their services have increased. He cites the examples of health care, law, finance, engineering, research and design. Likewise, the demand for manual task intensive occupations will also increase resulting in societal income. However, there will be turmoil in the middle-level jobs and that would require policy intervention.

The results of the study on ‘Average change per decade in US occupational employment shares for 1980–2010’ show decline in occupational employment shares in the following sectors: agriculture (this sector experienced much higher decline in the earlier decades starting from 1940), operative labour (this sector also has been experiencing decline for a long time), skilled blue-collared workers and clerical staff in sales. Among these only sales staff has been experiencing steady increase in employment share in decades before 1980 and could be attributed to the current technology and in particular to web-based commerce. On the other hand, there has been a phenomenal increase in the growth of employment among services and managerial staff. Growth among professional and technical persons has also been high. So the clear gainers are technical personnel, services and managerial staff.

Likewise, their chart showing change in employment by major occupational categories for the period 1979–2012, only labour employed in operations, production and sales experience declined. Sectors like personal care, food and professionals showed growth of employment. Data supports the conclusion that mechanization and artificial intelligence cannot replace professionals and personal care.

His results dealing with changes in occupational employment shares in low, middle and high-wage occupations in 16 European Union countries for the period 1993–2010 reveal a positive growth rates for low- and high-wage jobs. However, the growth rate is negative for middle-income jobs. For most European countries the decline was more than 10%. This led to his conclusion that many of the middle-skill jobs are susceptible for automation. Even here some of the middle-skill jobs like medical support occupations—radiology, technicians, nurse technicians and others showed rapid growth. In other words, there would be a shift in occupational structure in the middle category.

Certain other studies also predict loss of low- and medium low-skilled jobs. For example, Frey and Osborne (2017) based on an in-depth study of probability of computerisation of 702 detailed occupations drawing upon recent advances of 'Machine Learning' and 'Mobile Robotics' forecast that about 47% of US employment is in the high-risk category of job losses. Unlike earlier studies that predicted computerization in mainly routine tasks, this study argues that non-routine tasks like legal writing and track driving would also be automated soon. The study draws on recent developments in skills like machine learning, including data mining, machine vision, computational statistics and artificial intelligence. They suggest that as technology forges ahead workers should relocate from low-skilled jobs to tasks that are not susceptible to computerization like jobs that require creative and social intelligence. This would require skill upgradation and massive retraining.

3 Robots

The UNCTAD Policy Brief (2016) mentions the increasing use of Robots in the manufacturing sector and its implications for employment. The introduction of robots is not necessarily led by capital-rich and labour scarce developed countries. Labour-rich countries like China are in the lead. The Policy Brief presents their estimates of year-end operational stock of industrial robots for select countries and regions for the period 2013–2018. In their estimate, China leads with more than 600,000 units of industrial robots, followed by Republic of Korea and Japan—both less than 300,000 robots each. The whole of Europe and North America (United States and Canada put together) will have only about 300,000 robots. Other Asian countries, that is, excluding China, Korea and Japan will also have about 200,000 robots. South America and Africa will have negligible quantity of Robots. Thus the Asian countries will be dominating in the production and the use of Robots. China, in particular, has started using Robots in textiles and garments sectors. India should take note of this and plan accordingly.

With regard to the industrial distribution of Robots, automobiles dominate and accounts for a large share followed by electrical and electronics sectors. Metals and chemicals also use robots but much less than automobiles and electronics and electrical goods (UNCTAD 2016). However, the entry of robots in employment-intensive sectors like textiles and garments could change the current industrial distribution of robots. On the other hand, scholars like Arntz et al. (2017) and Mani (2017) are of the view that fears of unemployment due to the increasing use of robots are exaggerated. They argue that the studies that have been estimating the use of robots in some sectors like automobiles and electronics and consequent unemployment fears are based on 'occupation' based approach in classifying robot intensive sectors. Instead, they advocate 'task based' approach for analysing the impact of robots.

In their view, in sectors like automobiles, etc. the whole occupations are not automated and only certain job tasks are prone to automation. For example in the automobile sector (a sector that dominates the use of robots) robots are used only in specific tasks like welding and arc welding. They have not spread to other areas of automobile manufacturing in the past four decades. Tasks related to welding, in their view, are harsh and repetitive for human beings to perform. Thus occupation-based approach exaggerates the impact of automation on unemployment. Findings of Mani (2017), show that the Indian experience is not different from the international experience. In India also robots are mainly used in automobiles, plastics and rubber in tasks that are inhospitable for human labour and that require precision. Mani (2017) also argues that India might not suffer much by the automation of the textile sector and in particular garments. The software used in garments is very expensive and cannot compete with Indian labour. These are also used only in sewing which is already automated.

UNCTAD Policy Brief (2016) in the concluding part clearly states that the digital revolution cannot be stopped and hence it is important for the developing countries to take appropriate steps so that they benefit. To achieve this, the developing countries should embrace the digital revolution and redesign their educational system. Heavy investments in education and human resource development are important. Countries that neglect skill formation could become victims. Huge public investments in logistics and telecommunications and infrastructure are needed to take part in the revolution. Once human and ICT infrastructure is created, developing countries would develop an advantage in combining robots and three-dimensional printing. China is already doing this on a big scale.

4 Human Capital and Development

The ongoing digital and genomics revolutions are knowledge based and knowledge intensive wherein human capital plays a crucial role. In some respects, it is a continuation of the knowledge and information technology revolutions that blossomed in the last quarter of the twentieth century. Hence, one could draw lessons from research studies conducted in the past decade or two on the role of human capital in promoting growth and employment. Furthermore, several studies show that foreign direct investments (FDI) would promote growth and employment only in countries that enjoyed high quality of human capital. To represent human capital most studies use indicators like enrolments in high schools and universities to consider the role of education in influencing the growth of employment. In addition, indicators like life expectancy and mortality rates are used as indicators of the health of the population. Human development index would include both education and health indicators.

There are several cross-country studies using panel data techniques that link human capital and in particular knowledge and skill base of the workforce to growth of income and employment. They also show that in the absence of educated and knowledge-intensive workforce FDI inflows and technology transfers will not result in growth and reduce poverty. For example, Borensztein et al. (1998) using Panel data for two decades (1970–79 and 1980–89) for 69 developing countries found the role of human capital and in particular enrolments in education crucial in explaining growth rate of incomes. Moreover, FDI by itself did not contribute to growth but when FDI and human capital were used in a multiplicative form it turned out to be significant. This was so even during the early stages of knowledge revolution. Wang (2009) using data from 12 Asian economies over the period of 1987–1997 found that FDI in manufacturing alone contributed to the growth of per capita income in the presence of human capital. FDI in service and nonmanufacturing sectors did not contribute to growth. In other words, mainly countries that concentrated in education and health achieved higher growth. Similar results are also found for cross-border mergers and acquisitions (Wang and Wong 2009).

Studies for India based on interstate differences in the growth of employment also found enrolment levels in higher secondary schools important in explaining growth of employment.

Bhat and Siddharthan (2012) analysed determinants of interstate differences in the growth of labour productivity and employment for the period 2003–2007. The human capital variable was represented by the proportion of students in the age group of 14–18 years in the schools. This variable was the most important variable determining interstate differences in the growth of employment in the manufacturing sector. This variable was also significant in explaining growth of labour productivity. Thus, the Indian states that ensured attendance in schools of students in the age group of 14–18 enjoyed higher employment growth rates. In the Indian case, growth of labour productivity and growth of employment went together as both were driven by the skill and knowledge base of the population. The major four states of India that have a heavyweight in the Indian Parliament, namely, Uttar Pradesh, Bihar, Madhya Pradesh and Rajasthan, are lagging behind in human development index and in particular education facilities. These states receive less investment both domestic and foreign and they also lag behind in the growth of employment. They are the victims of the knowledge revolution and to avoid further decline and the consequent adverse consequences they should go in for a crash programme aimed at human resource development. A more recent study by Bhat (2018) reinforces this conclusion. Her study finds interstate differences in education levels the main determinant of the growth of employment, wage and salaries.

In addition to emphasizing the importance of education and skill levels at the entry point of employments, studies also point to the importance of in house training. In an era of fast technological changes continuous upgradation of skills of the workers already employed is essential. The study by Shampa Paul and Kaushalesh Lal (2018) based on 2011–16 Indian data shows that expenditure by the firms on welfare and training of workforce has positive and significant influenced on employment generated by the firm. Thus firms that have been employing more persons have been spending on skill upgradation.

Product Creation, Process Innovation and Employment

The role of human resources is very important in the creation of new products and processes. Human resources play a crucial role in R&D, manufacturing and commercialization of the products. Some scholars like Calvino and Virgillito (2018) argue that R&D resulting in the creation of new products fits into the Schumpeterian concept of 'creative destruction' as new products could replace the earlier products. However, process development is more like 'creative accumulation'. Calvino and Virgillito (2018) based on their survey literature in this area conclude that at the firm and industry level new product creations contribute to employment at the firm and industry level. This is particularly so for high-tech industries. In these cases, product innovation and employment growth are positively correlated. Studies further show that despite the creation of new products resulting in the destruction of the older products employment even at the micro-level does not suffer.

However, the results for the process innovations and employment are mixed. Studies show that either they are not related or they harm employment growth. Several of these studies tend to show (Calvino and Virgillito 2018) a negative covariation between process innovation and employment. This could be because process innovation and productivity are highly related. Studies also show that the relationship between process innovation and employment is more complex and several issues need to be sorted out before deriving conclusions. In this paper, we are mainly concerned with product innovation and employment and they are positively related.

5 Outward Foreign Direct Investment, Outsourcing and Employment

Information Technology and digitalization facilitates networking and promotes global manufacturing. As discussed by Chen (2010), in the globalized world different segments in the production chain could be split and undertaken in different countries based on efficiency of production. Chen gives the example of integrated circuits, where the designing could be in the US, chips production in another country and the final consumer of chips could be large electronic corporations belonging to a third country. This could be achieved either through licensing or FDI depending on the transaction costs involved in technology transfers and production transfers. This practice has now become a political and electoral issue in the developed countries.

Outward FDI is accused of creating employment in other countries and declining employment in the home country.

There were widespread fears in Europe regarding transferring of low-tech manufacturing jobs to cheap labour countries. It was argued that outward FDI would result in deindustrialization and unemployment in Europe. In this context, the study by Navaretti et al. (2010) shows that for France and Italy there were no adverse impacts. In fact, productivity and employment increased in the medium run. The paper examines the impact of outward FDI on employment, gross output, and value added, total factor productivity of what the authors call the economic activities maintained at home by the investing firms. They estimated a multinominal logit model and computed propensity scores for three possible scenes, namely, 1. not investing abroad, 2. investing in developing countries and 3. investing in developed countries. For[1] both France and Italy they find no negative effect on investing abroad on firm performance. For Italy, they find a significant increase in total factor productivity of the Italian (home country) firms 3 years after investing in a less developed country. Employment dropped slightly (not statistically significant) immediately after investment but recovered fast and after 3 years was higher by 8 percent compared to the controlled group.

European investments abroad could be to expand business and penetrate distant markets. The firms could retain their core areas of competence at home and shift only non-core areas to foreign locations. This will not reduce employment at home. Federico and Minerva (2008) analysed the impact of outward FDI on local employment for Italy. The analysis was carried out for the period 1996–2001 covering 103 Italian administrative provinces and 12 manufacturing industries. They found that employment in provinces that specialized in a single industry did not grow. On the other hand, employment in provinces with diversified industries (they took the inverse of H index) grew faster. With regard to OFDI, outward investment to the world and to developed countries contributed positively to employment growth. The coefficient of investment to less developed countries was not statistically significant in explaining employment growth.

A more recent study by Valacchi and Doytch (2018) and Doytch and Valacchi (2018) show that firms that have been investing abroad and patenting are also the ones that have been creating jobs. In other words, job creation, patenting and OFDI go together.

By and large, empirical studies do not support the concern of some policymakers of developed countries about the adverse impact of outward FDI to other countries and in particular to low-wage countries. In a globalized atmosphere, it is not advisable to produce all products and components in a single country. Locating some of the non-core activities in other countries mainly improved the competitiveness of the local firms and enhanced the employment opportunities.

[1] It is reused from http://esocialsciences.org/eBook/eBook_Siddharthan.pdf with permission from eSocialSciences.

6 Shape of Things to Come

This section is based on the vision of the scientists as expressed by Anthes (2017) in the science journal *Nature*. She includes artificial intelligence, robotics and cloud computing under digital technologies and is of the view that it would transform almost all sectors from agriculture, medicine to manufacturing to sales, finance and transportation. This was also true of the information technology and computer revolution. It also affected all sectors and countries. As discussed in the introduction all major technological revolutions would affect jobs and several jobs would be destroyed. At the same time several new jobs would be created. As rightly observed by Schumpeter, development is turmoil. The role of policy during the period of creative destruction is to identify the areas of creation and prepare the workforce to participate and benefit. This would also involve retraining of persons to suit the needs of technological change.

By and large, scientists are more positive about the ongoing digital revolution and argue that unemployment fears are exaggerated. Their main argument is that current research and international business involve collaborations across countries and face-to-face interaction in the work units. Machines will fail in both the cases. We saw in Sect. 5 that thanks to the digital revolution transaction costs have radically come down and the production process has drastically changed. Different stages of the development of the product are done in different countries either by the same enterprise or by different enterprises depending on transaction costs involved. Participation in the global production network would involve frequent interactions and collaborations by different teams. Machines are not good in carrying out processes where collaborations and interactions are important. However, workforce needs to be retrained. In the future world, people need to collaborate and need to know each other better. Standalone solo workers would disappear.

In areas like health and medicine also as observed by Anthes (2017), if automated systems start making routine medical diagnoses, it could free doctors to spend more time interacting with patients and working on complex cases. They will become better doctors. It will not replace doctors. The same is true of paramedical staff. However, doctors will also have to undergo retraining in handling medical equipment and increase their knowledge of genomics. The gene revolution can also help in identifying rare genetic diseases and help in their treatment through genetic modifications. Web-based technology would also help the doctors to locate and identify other patients suffering from similar disorders in other parts of the world and examine the effectiveness of their gene treatments.

A Report of the World Economic Forum (Partington 2018), states that rapid technological advances over the next decade would create 133 million new jobs globally and would only displace 75 million jobs. Thus it will create double the number of jobs than it would destroy. It cites the similarities with the earlier steam and electricity revolutions where it created more jobs than it destroyed. However, it would require greater investment in training and education and creation of safety net for the victims.

7 Opportunities for India

As emphasized by scientists the technological revolution cannot be stopped. The only option available to India is to look for opportunities that are available and plan appropriate strategies to benefit from technology. In its absence, India could become a victim. Fortunately, there are several aspects that India could exploit to its advantage provided India realizes the importance of skill intensity and train its workforce in the skills required.

Quantum Computers

Quantum computers are likely to emerge in a decade or two. They will revolutionize the Information Technology sector and India has a good opportunity to participate and benefit by contributing to the production of both hardware and software. The current computer technology is based on 2-digit bit configuration while the quantum computer is based on 3-digit configuration. In effect, there will be a movement from BIT to QUBIT. This will facilitate 'n' parallel processing and simultaneous presence in more than one place. When the quantum computers come most of the existing hardware and software developed for the current computers cannot be used. This gives enormous opportunities for Indian software experts. This is much more than what Y2K offered. That was once for all correction. The quantum of software for the quantum computers will be several times more and will also be a continuous process. India could also enter the hardware market. Currently, the Indian share in the hardware market is not significant. However, India could leapfrog to the future technological world. It is important to train the technologists in quantum physics and its computer applications.

Solar Energy

Technological change in solar energy has also been rapid. Bulky and unwieldy inefficient solar panels are now being replaced by thin-film panels. These are also more efficient in converting solar energy to power. Quantum dots are also likely to emerge. Sooner or later printed solar cells that are paper thin, lightweight and extremely inexpensive to produce are likely to emerge (Pardos 2017). They are labour intensive in their operations and India can again leapfrog.

Three-Dimensional Printing

Three-dimensional printing is another area where India could benefit. At present, it is mainly used in biomedical devices such as surgical planning, prosthetics and applications (Rengier 2010), and bone tissue engineering (2013). It is likely to spread to other sectors soon. The process is labour intensive and Indian workers could be trained in this area.

It is important to identify areas where India could have potential advantage and prepare for effective participation.

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