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INDUSTRY 4.0 AND IMPLICATIONS FOR SKILLS DEVELOPMENT IN MANUFACTURING AND SERVICES SECTORS OF INDIA

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Abstract: In the last over five decades, technological transformation has changed economic world drastically. Currently, the world is experiencing substantial penetration in digital innovation. The ongoing process of technological upgrading is termed as Industry 4.0. Industry 4.0 refers to high speed and profound alternation of new technologies, which significantly changed the employment markets. The growth of digital technologies can be a highly advantageous to Indian labour market, if India plan tap these digital opportunities specifically the digital economy through education, e-business, digital payments, and other relevant technologies. However, the Industry 4.0 also pose novel barriers such as the scarcity of skilled labor with adequate qualifications. Therefore, India should plan to leverage the skills and training to meet the needs of labour market in the context of the Industry 4.0. The acquisition of necessary skills can bridge the skill gaps in Indian labour market. There is need to match the skills demand and supply to foster the mobility of skilled labour and vocational and university graduates with the Industry 4.0-compatible skills in labour market. Besides vocational and university education, on-the-job training must creates necessary technical and practical skills for the Industry 4.0-compatible Indian labour market. There is need to bolster skills mobility in high demand vocational occupations rather than workers with threshold skills. With above backdrop, the paper reviews the impact of the Industry 4.0 technologies on skill flows and labour mobility in developing economies, and draws skills implication for manufacturing sector such as garment manufacturing and services sector like tourism, and ascertains the potentials and challenges of the Industry 4.0 technologies for growth and labour market. Lastly, some policy implications have been drawn for skills development and labour market in India and offered direction for future research.

Keywords: Industry 4.0, Future of Labour Market, Skills Development, Manufacturing Industry, Service Sector, India

JEL Codes: J01, J21, J24. L60, L80

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I. INTRODUCTION

In the last over five decades, technological transformation has changed economic world drastically. Currently, the world is experiencing substantial penetration in digital innovation. The ongoing process of technological upgrading is termed as the Industry 4.0. The Industry 4.0 or Industry 4.0 refers to high speed and profound alternation of new technologies, which significantly changed the employment markets (Schwab, 2016). The growth of digital technologies can be a highly advantageous to Indian labour market, if India plan tap these digital opportunities specifically the digital economy through education, e-business, digital payments, and other relevant technologies. However, the Industry 4.0 also pose novel barriers such as the scarcity of skilled labor with adequate qualifications (ILO and ADB, 2014). Therefore, India should plan to leverage the skills and training to meet the needs of labour market in the context of the Industry 4.0 (WEF and ADB, 2017). The acquisition of necessary skills can bridge the skill gaps in Indian labour market. There is need to match the skills demand and supply to foster the mobility of skilled labour and vocational and university graduates with the Industry 4.0-compatible skills in labour market (ADB, 2017a). Besides vocational and university education, on-the-job training must creates necessary technical and practical skills for the Industry 4.0-compatible Indian labour market. There is need to bolster skills mobility in high demand vocational occupations rather than workers with threshold skills. With above backdrop, the paper reviews the impact of the Industry 4.0 technologies on skill flows and labour mobility in developing economies, and draws skills implication for manufacturing sector such as garment manufacturing and services sector like tourism, and ascertain the potentials and challenges of the Industry 4.0 technologies for growth and labour market. Lastly, some policy implications have been drawn for skills development and labour market in India and offered direction for future research.

II. REVIEW OF LITERATURE

The Industry 4.0 technologies can potentially impact future of the labour markets (Sima *et al.*, 2020). The Industry 4.0 refers to increased application of novel technologies for greater quality, improved efficiency and enhanced productivity (Ulewicz and Novy, 2017; Stasiak-Betlejewska *et al.*, 2018). The Industry 4.0 aims to improve operational efficiency and effectiveness through increased automation (Nagy *et al.*, 2018). It will embrace smart technologies for high speed communication and development of new business models (Maresova *et al.*, 2018). The Industry 4.0 facilitates enterprise development by reducing operational and production costs,

thereby increase the profit and productive efficiency of the firms and stimulates their participation in GVCs.

Automation will alter the skill needed for industry. More technological skills will be needed compared to basic cognitive skills. New technological skills can be enhanced and cannot be substituted. Automation cannot be always labour displacing, but reduce work force's contribution to value added (Autor and Salomons, 2018). There is exaggeration of job automation and substantial number of tasks is not easy to automate (Arntz *et al.*, 2016). New technologies can automate the tasks and cannot automate the jobs, which require new skills to perform the task (Susskind, 2020). Besides positive impacts of new technologies on productivity and skills, new technologies can generate negative consequences for the labour markets and jobs (Bandura and Hammond, 2018). The Industry 4.0 technologies can impact work procedures and place of work (Ross *et al.*, 2017). Technological transformation can change production and distribution of goods to production of services (Adeney, 2018), thereby require new compatible professional skills for future labour markets (Balliester and Elsheikhi, 2018). The Industry 4.0 impels the need for quality skills training to embrace new technologies in developing countries to tackle skills shortages (Ayentimi and Burgess, 2019).

In optimistic sense, the Industry 4.0 provides numerous opportunities for labour markets (World Economic Forum, 2016). But at the same time, it may weaken labour standards, create labour market insecurity, generate inequalities, and corrode labour institutions (De Ruyter *et al.*, 2019; Rainnie and Dean, 2020; Stanford, 2017). The Industry 4.0 technologies can potentially impede the supply of skilled labour (ILO, 2017; Searle, 2019). Educated youth face several difficulties in labour market transitions due to youth's skills mismatches. Many developing countries lack transitional support mechanisms for smooth labour market transitions. Along with skills mismatches, the overqualified graduates also fail to access jobs (Prikshat *et al.*, 2019).

The Industry 4.0 also face the dilemma of short-run vision of many firms. Most enterprises lack readiness to embrace automation due to lack of leadership and innovative vision (EIU, 2018). However, Nankervis *et al.* (2020) revealed that China, India, Thailand and Singapore have shown considerable progress toward the Industry 4.0. The Industry 4.0 technologies induced gig work demonstrates the uncertainties and inconsistencies of the Industry 4.0 and its impact on labour market due to employment regulation (Stewart and Stanford, 2017; Van Barneveld *et al.*, 2020) and corroding labour standards (Stanford, 2017). Most of the gig works are short duration and infrequent and likely to be second jobs.

Autor and Dorn (2013) emphasized on the occupational tasks viz. routine tasks (performed regularly and easily standardized) performed by low-and-medium skilled workers, and non-routine tasks (problem-solving and complex communications) carried out by high skilled workers. In the United States, a significant share of workers in middle-skilled service occupations is at high risk of automation (Frey and Osborne, 2017). In many ASEAN economies, more than half of workers in routine tasks are experiencing risk of technological displacement (Chang and Huynh, 2016). In the Philippines, nearly half of workers in process-driven tasks in business process outsourcing sector are likely to be threatened due to novel technologies (AfDB *et al.*, 2018).

Stewart *et al.* (2015) argued that new technologies can create new jobs in existing occupations. In developing Asia, non-agricultural sector created substantial employment in over three decades due to technology-induced productivity (ADB, 2018) and greater participation in global value chains (GVCs) (ADB 2017b). However, the Industry 4.0 technologies are likely to decrease employment within GVCs in developing Asia (Bertulfo *et al.*, 2019). But increase in middle- and upper-income classes and consequent surge in domestic demand can substantially increase future employment in developing Asia (Kobayashi *et al.*, 2017). However, it is difficult to project the distribution of increase in future employment in terms of non-routine cognitive and manual occupations, and routine cognitive and manual occupations due to technological upgrading of GVCs. Besides, urban-rural distribution of employment is also significant. Urban regions have greater proportion of skilled workers than rural areas which are experiencing labour displacement (McKenzie, 2017). Urban areas also attracts high-skilled workers in high-income jobs to work remotely on digital platforms and Industry 4.0 technology, which increase skilled migration (Graham *et al.*, 2017) to advance their skills and is termed as transit migration. Transit migration refers to migration of persons with tertiary education to a country or region who lived in a country or region other than their birthplace prior to their arrival (Artuc and Ozden, 2018). Besides, the Industry 4.0 has led to surge in temporary and circular-skilled migration due to better transport and communication.

The Industry 4.0 fosters migration of work with no migration of labour force (Hamel, 2009) through virtual migration (Aneesh, 2006) to perform tasks from anywhere (Graham *et al.*, 2017). However, the gig economy can be beneficial for certain occupations in high demand and can make the vulnerable workers more at risk of the Industry 4.0 (Balaram and Stephens, 2018). The Industry 4.0 characterizes significant changes application of technologies for economic activities (Schwab, 2016). The key elements of

the Industry 4.0 include greater connectivity, better analyzing, and digitalization (Park, 2017) as well as artificial intelligence (Lee *et al.*, 2018).

During the Industry 4.0, many jobs will be performed by artificial intelligence (Frey and Osborne, 2017). Significant proportion of existing jobs will cease to exist in future and will be replaced by new jobs (WEF, 2016). In this scenario, what should be done to be employable (WEF, 2018) in the context of declining regular work hours and surge in the non-standardized work hours (Aleksynska and Muller, 2015) with the emergence of telework (Messenger and Gschwind, 2016) without face to face interaction (Baldwin, 2019).

The Industry 4.0 will increase the number of crowd workers (Wobbe, 2016) with greater digitalization (Park, 2017) and application of artificial intelligence (Jarrahi, 2018). Therefore, skilling, upskilling and reskilling in the Industry 4.0-compatible technologies are paramount to be employable (WEF, 2018). At the same time, the Industry 4.0 technologies can drastically reduce jobs in future (Hirschi, 2018). It is estimated that one-third of jobs will likely to vanish by 2025 (Brougham and Haar, 2017) due to inadequate employability skills (Teng *et al.*, 2019). New skills in sense-making, social abilities, creative thinking, digital literacy, and virtual cooperation are needed for current and future jobs (Davies *et al.*, 2011). The robots and machines are likely to perform most of the repetitive and physical tasks (Frey and Osborne, 2017). Therefore, higher education and skills in the Industry 4.0 technologies can facilitate better employment compared to lower educational attainment.

The Industry 4.0 technologies can support development of robust labour market policy facilitated by data and information. The use of online platforms and application of artificial intelligence and machine learning can offer better market analysis and development of Industry 4.0-compatible labour market policies. At the same time, substantial reskilling and retraining of workers will be required to match skills in existing occupations and new skills for future occupations. This will necessitate greater application of digital technologies in teaching and learning (Sarvi and Pillay, 2017).

III. THEORETICAL UNDERPINNING OF THE INDUSTRY 4.0 AND SKILLS IMPLICATIONS FOR LABOUR MARKET

III.1. Phases of industrial revolution

There are four phases of industrial revolution. The first phase of industrial revolution (1IR) begins from the end of the 18th Century to late 19th Century

and was characterized by mechanization and the use of steam power, where the production activities were concentrated in agriculture, textiles, and other simple mechanized and steam-driven power. The second phase of industrial revolution (2IR) starts from the late 19th Century to mid-20th Century and experienced advanced mechanization and mass production driven by electric power generated mainly by fossil fuels and has seen surge in white-collar jobs and mass consumerism and growth in public services. The phase of third industrial revolution (3IR) begins from the mid-20th Century to the beginning of 21st Century and experienced substantial growth in information and communication technologies (ICTs), , which were drive by rapid surge in computing power. This phase led to rapid growth of economic globalization and development and integration of value chains in both the manufacturing and service sectors. The current phase of industrial revolution is termed as the Industry 4.0, which begins in the early 21st Century and continuing. The Industry 4.0 is characterized by rapid penetration of digital technologies in businesses, public services, and society at large. This phase is driven by substantial development of novel technologies such as artificial intelligence, robotics, machine learning, internet of things, and data analytics. The Industry 4.0 has challenged the contemporary business models, which have significant implications on the future economy, education, employment and the labour market (see figure 1). The figure 2 illustrates the main Industry 4.0 technologies.

III.2. Industry 4.0-compatible tasks and skills relevant to manufacturing and services

In the following paragraphs, the relevance of the Industry 4.0-compatible tasks and skills in garment manufacturing and tourism sector in developing

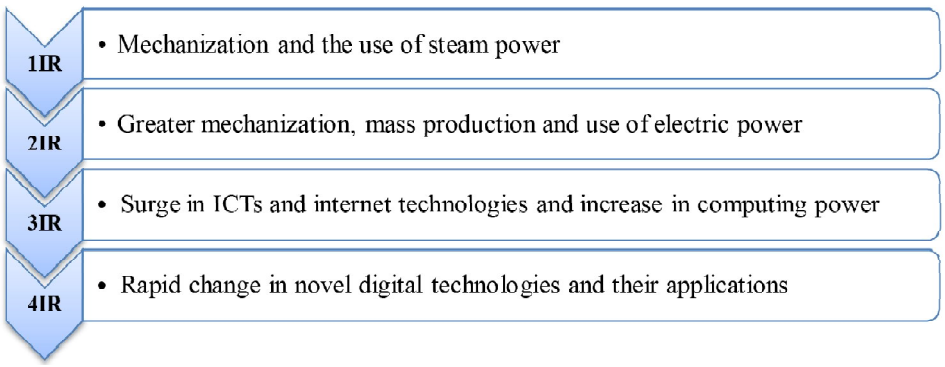

Figure 1: Phases of Industrial Revolution

Source: Author's creation

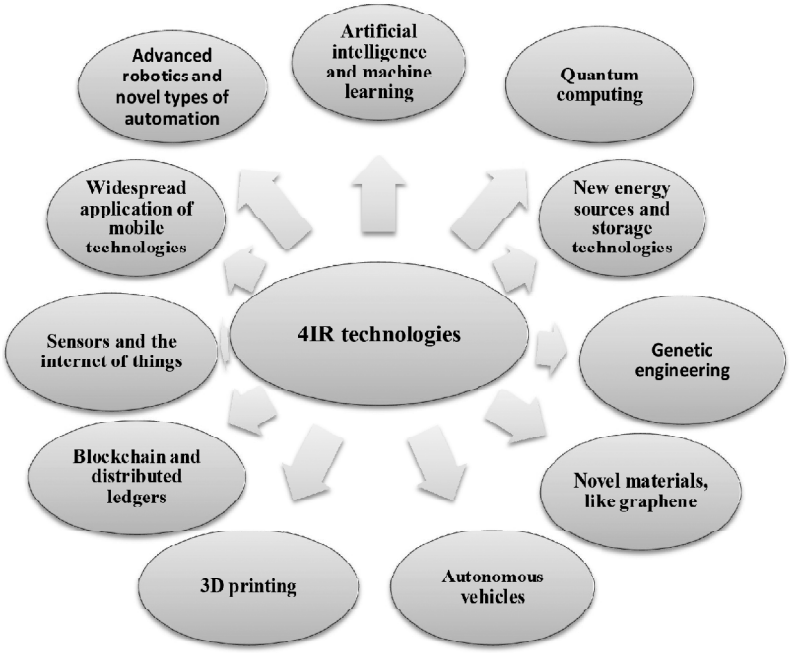

Figure 2: Industry 4.0 technologies

Source: Author's creation

countries like India have been presented. It is likely that five job tasks in garment manufacturing can be impacted by the Industry 4.0 (see figure 3).

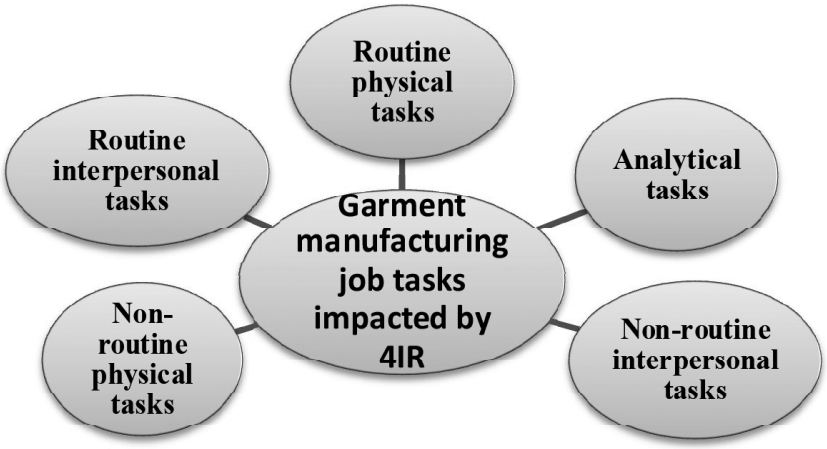

Figure 3: Garment manufacturing job tasks impacted by the Industry 4.0

Source: Author's creation

Figure 4: Industry 4.0-compatible skills implications

Source: Author's creation

In the garment manufacturing, routine physical tasks such as the recurring and conventional physical labour, routine interpersonal tasks such as expected communications with other workers for sales, non-routine physical tasks such as recurring or conventional physical work on machines and engine repairs, non-routine interpersonal tasks such as multifaceted or imaginative communications with other workers in managing various tasks, and analytical tasks such as critical thinking can be impacted by the Industry 4.0 technologies like application of computers or other technologies (see figure 3). It is likely that routine interpersonal tasks will increase and routine physical tasks will decrease. The team work activities are likely to be demanded more compared to isolated work in garment manufacturing. These changes in various conventional tasks will generate significant implications for the Industry 4.0-compatible skills requirements in garment manufacturing (see figure 4).

The changes in tasks requirements in garment manufacturing can strongly impact the cumulative skills to meet the needs of Industry 4.0-compatible technologies. The novel skills requirements include critical thinking and active learning for application of logic and reasoning for problem solving and decision-making. The written and verbal communication skills including ability to read, write, speak, and actively

listen are essential to stay in jobs. Similarly, numerical skills such as ability to apply mathematics and scientific techniques for suggesting solution to the problems become necessary. The skills for complex problem solving are essential to understand, review, develop and evaluate alternatives. The management skills related to financial, material, personnel aspects are also needed. The social skills for effective cooperation, training, conciliation, motivation, and compassion will also be required. The workers will require skills in effective appraisal, reasoning and judgment for better understanding and decision-making. Technical skills in developing blueprint to design, manage and rectify faults will be required for using new machines and technologies. In this digital age, skills in computer literacy to apply digital technologies for effective communication, and data mining and analysis will becomes highly relevant to stay in employment. Not only basic computer abilities will be needed, rather advanced skills in application of digital techniques and ICTs will become highly relevant to accomplish complex tasks such as using complex spreadsheet, financial software, graphics, and programming.

Besides, manufacturing sector, the Industry 4.0 can also impact the skills requirements of the service sector like tourism. Tourism sector is already embracing digital transformation at rapid rate. Most of travel bookings are done online or via smart phones. The Industry 4.0 technologies can substantially impact the value chain of tourism sector through significant implications for skills of workers. The Industry 4.0 technologies such as big data analytics and simulation techniques can widely improve the service provisioning in tourism sector. The key Industry 4.0-compatible skills requirements in tourism service delivery are shown in figure 5.

The artificial intelligence technology skills have strong implications for facial recognition and biometric data skills needed for identification verification of customers and providing them better personalized services and safety. The selfie pay system is already in practice by MasterCard. Blockchain technology skills can be used for retrieving and accumulating the vital information of the customers such as payment, passport, and baggage details. The Internet of Things skills can be used to offer personalized services, accurate baggage information, and security services to customers. Big data skills can be used to forecast the occupancy rates and understand the customer income groups for future planning. Industry robotics skills can be successfully used for providing better services in tourism sector. Robots can be engaged for arduous tasks like waiters, sanitary, and waste disposal. Virtual reality skills can be used by service providers in tourism sector.

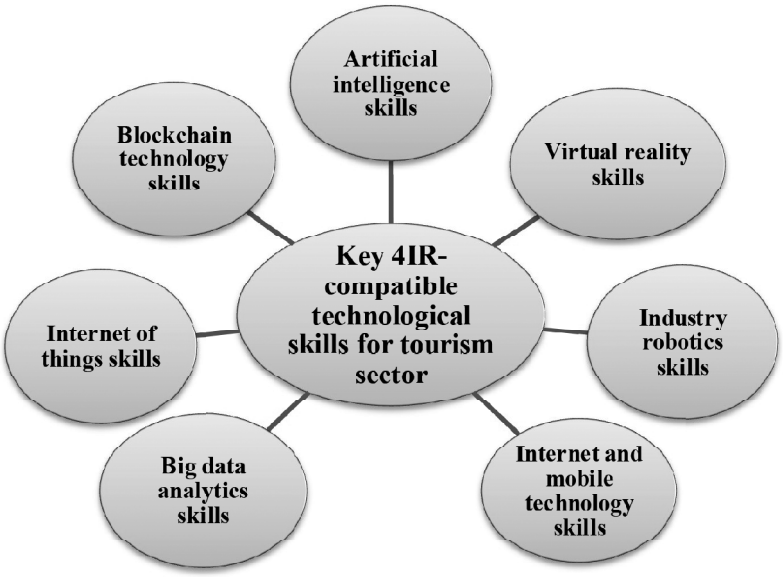

Figure 5: Key Industry 4.0-compatible technological skills for tourism sector

Source: Author's creation

III.3. Key opportunities and challenges of the Industry 4.0

The States and the Union Territories of the Indian Union are highly diverse in economic and social terms. The Industry 4.0 is likely to bring numerous opportunities and challenges with significant implications for skills development and labour market outcomes, which are illustrated in figure 6 and figure 7 respectively.

The Industry 4.0 technologies can increase income and wealth via improved efficiency and productivity, massive increase in consumer choice, lower the costs, and increase the quality of the life. Economic inclusion can be bolstered through improved digital connectivity, better access to services, speedier financial inclusion, increase access to novel information, develop new online educational platforms, and new healthcare services. The Industry 4.0 can bolster the small and medium-sized enterprises (SMEs) by greater access to finance, business services and information, surge of digital platforms and digital services, expansion of trade, transformation of payments and logistics, and development of e-commerce. The infrastructure needs can be reduced in fixed landlines, lower the cost of mobile phones, develop online and mobile banking, greater production of renewable energy locally, greater use of new battery storage technology for solar power, reduce the investment in expensive power distribution networks, supply high-value goods through drones and using drones to design transport

infrastructure. The Industry 4.0 technologies can enhance digital connectivity, improve access to electricity through local new renewable energy technologies, application of 3D printing to manufacture products at small scale, facilitate high-speed internet to remote communities, increase the connectivity through high-speed broadband, increase health supplies through drone delivery, and develop automated aerial logistics. It has substantial potential for better traffic management, which can reduce traffic congestion, increase safety and security via self-driving vehicles, and reduce pollution through smart urban transport systems.

Better environmental management can be facilitated by application of the Industry 4.0 technologies to monitor resource use through application of artificial intelligence. Similarly, drones and remote sensing techniques can be use to increase irrigation efficiency through automated system. In agriculture transformation, the Industry 4.0 technologies have immense applications, for instance, use of digital technology to improve farm productivity and profitability, enable sharing economy to access mechanical equipment using smart phones, improve the products traceability to reduce the risks of food contamination, reduce transactions costs through e-payments, greater use of new logistics applications for efficient trucking services, improve agricultural finance through use of new credit-scoring technologies, and application of microbiology in farming systems. Enhance health and healthcare systems can be achieved by application of the Industry 4.0 technologies in delivering health services via telemedicine, remote collection of health data, and lower expenditure on health treatment through precision medicine. Last but not the least, the Industry 4.0 technologies can led to better disaster preparedness through efficient tracking of carbon emissions and development of carbon markets, and deliver aid to worst affected communities through drones.

Besides enormous opportunities of the Industry 4.0 technologies, it has substantial challenges for employment and labour market. The Industry 4.0 technologies can result in enormous job losses and disruption in the labour market due to the application of artificial intelligence and robotics, and pose substantial dangers to low-skilled and repetitive jobs. Increase in automation can increase short-term unemployment, economic migrants and inequality and pose high cost of retraining and skills development. The job losses and disruption in labour market can cause social and political instability due to non-inclusive growth and reduce popular support and political trust. The Industry 4.0 technologies can be a big blow to mass manufacturing due to decline of low-cost and low-skilled manufacturing, and reshoring of production. New technologies can increase the concentration of economic power, create difficulties for larger domestic

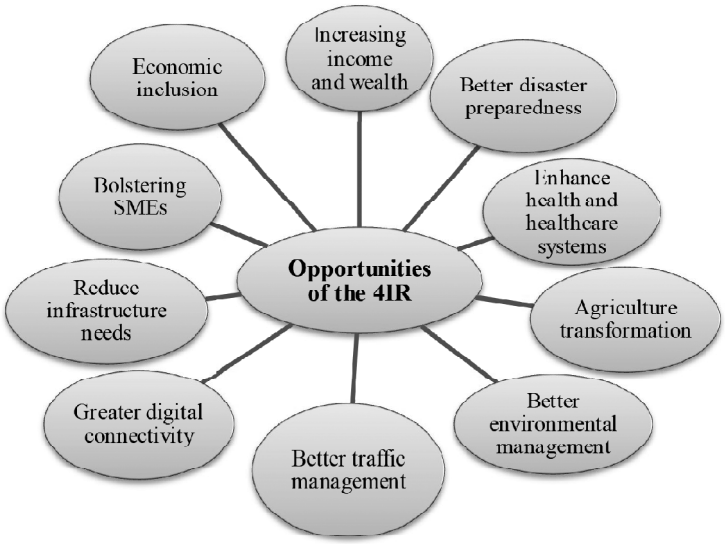

Figure 6: Opportunities of the Industry 4.0

Source: Author's creation

businesses, and increase the competition from platform businesses and also increase the exposure and vulnerability to cyber attacks due to greater application of digital tools. All this call for developing mitigating policies to increase the returns from the applications of the Industry 4.0 technologies and reskilling the displaces workforce, upskilling the new job entrants and reorient the technical and vocational education including the general education to equip the future workforce with the Industry 4.0-compatibale skills.

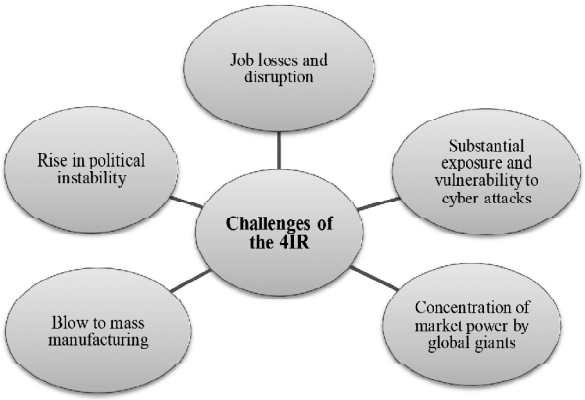

Figure 7: Challenges of the Industry 4.0

Source: Author's creation

IV. POLICY IMPLICATIONS

The Industry 4.0 technologies have substantial implications for growth and the labour markets (Herweijer *et al.*, 2017). Therefore, there is need to mitigate the unintended adverse consequences for labour markets. Strong labour market regulations and skills development and trainings are needed to enhance the agility and ability of the workforce to exploit the strength of the Industry 4.0. A holistic approach is needed for collaborative actions of the government and relevant ministries to reap the opportunities presented by the Industry 4.0. The technologically displaced workforce needs reskilling and retraining through appropriate institutional development in the Industry 4.0-compatible technologies. The digital infrastructure should be developed through stronger public-private participation. There is need to reorient the technological policies, labour markets, and educational policies to maximize the outcomes of the Industry 4.0. Strong government–industry collaboration is essential for the Industry 4.0-compatible skill development for sustainable and decent jobs.

There is need to evolve the policy mechanism for stronger cooperation and integration among the States and Union Territories of India to expand labour markets for development of SMEs. This can foster the SMEs to source workers and the Industry 4.0-compatibale skills from a bigger pool. The robust cooperation and collaboration among the States and Union Territories can generate novel collaboration opportunities for the Industry 4.0-compatibale skills development in cost-effective ways. The collaboration among the States and Union Territories can address the challenges of the Industry 4.0 technologies, capture the opportunities and manage the associated risks, for which following suggestions should be embraced.

IV.1. Data and information sharing

Robust data and information sharing is the basis of the Industry 4.0 technologies. The capacity to transfer data and information and their accessibility across the States and Union Territories is essential to embrace the Industry 4.0 technologies successfully. Individuals, SMEs and the governments require uninterrupted flow of data and information and their processing and storage to supply the services and harvest the advantage of the Industry 4.0 technologies. This can facilitate the supply of required skills and greater absorption of skilled labour in the Industry 4.0-compatible businesses and economic activities using sensors and the internet of things. The performance and efficiency of new machines can be supervised remotely, if the workforce possesses the necessary skills. Data locking and information barriers pose substantial challenges to the individual and the

SMEs to succeed in the new technological era. Therefore, novel ways must be explored and developed to smooth the flow of data and information across the States and Union Territories. Despite enormous advantages, the data flows across the States and Union Territories can also pose challenges linked to private and susceptible information like financial operations. Other associated challenges can be linked to data safety, secrecy, and intellectual property rights. In this context, the physical location of servers is not important. Rather, the protocols and rules governing the data accessibility, use and storage are vital. Therefore, robust rules and regulations for data governance are needed for smoother data flows across the States and Union Territories, which should be crafted through stronger collaboration.

IV.2. Trade and manufacturing

The Industry 4.0 technologies have increased trade transformation from physical goods to digital goods. Besides digital media products, the manufacturing products like engines and spare parts are transforming to virtual mode. Suppliers are displacing manufactured goods by blueprints and designs and producers are using 3D printers to manufacture the goods. These transformations have strong implications for industrial policy in the States and Union Territories. Therefore, profound cooperation is needed to formulate new industrial standards and manufacturing safety regulations across the States and Union Territories.

IV.3. Service standards

The Industry 4.0 has led to surge in trade in services compared to trade in goods. Remote healthcare facilities are emerging from centres of medical excellence at low cost across the States and Union Territories using new technologies such as Bluetooth. This requires novel standards and transparent rules governing healthcare services across the States and Union Territories.

IV.4. Complementary business environment

The success in the Industry 4.0 require facilitating digital platforms and infrastructure services like financial institutions, digital payment platforms, online businesses and logistics services to operate on national scale to reap the economies of scale and networking benefits. This entails complementary business laws and regulations across the States and Union Territories.

IV.5. Reorienting fiscal policy

The growth of digital products and services pose substantial fiscal challenges for levying and collecting taxes across the States and Union Territories.

Stronger cooperation across the States and Union Territories is needed to define tax rules for new commercial operations.

IV.6. Innovative incubators

The success in the Industry 4.0 requires development of more innovative SMEs and startups through creation of innovation hubs and incubators across the States and Union Territories. There is need to increase the scale of business operations and promote stronger competition by linking innovative incubators across the States and Union Territories into a national networks for developing new business opportunities.

IV.7. Stronger education networks

Educational transformation is critical for mitigating job losses and skills disruption due to the Industry 4.0 technologies. The skills in technical ability, creativity and novel problem-solving are essentially Industry 4.0-compatibale skills. The Industry 4.0 technologies entail substantial impact on labour market. The future workers are likely confront multiple jobs rather than a single career, which calls for stronger emphasis on lifelong learning rather than only academic education. The New Education Policy has recognized the significance of adult learning and lifelong learning, which should be bolstered through stronger education network across the States and Union Territories. The New Education Policy also emphasize on credit-transfer systems between the universities across the States and Union Territories, which would facilitate the development of personal and professional networks for future workers across the States and Union Territories. The COVID-19 pandemic has induced the relevance of online education and remote access to education opportunities, which should be strengthened through educational network across universities for development of the Industry 4.0-compatibale skills among the future workforce.

IV.8. Promoting labour mobility

The Industry 4.0 technologies entail greater access to skilled manpower and their mobility across the States and Union Territories can facilitate the demand of Industry 4.0-compatible skills. The existing system of reciprocal acknowledgement for professional and technical qualifications across the States and Union Territories should be strengthened by including Industry 4.0-compatible occupations through suitable regulations.

IV.9. Supporting stronger gig economy

In the Industry 4.0 world, many individuals work as self-employed

consultants in the gig economy. The stronger gig economy has the capability to provide immense new job opportunities, which entails stronger data management, tax rules, and social protection through robust governance, policy and regulation.

V. FUTURE RESEARCH DIRECTION

The Industry 4.0-compatible skills mismatch is high in India, which require substantial attention to reskilling and skills mobility. Therefore, there is need to understand the recent growth performance and employment trends and how future growth will impact the Industry 4.0-compatible skills and labour market in India. How the government can support development of talent clusters to increase the supply of highly skilled workforce? What types of enabling environment are to be created to development highly skilled workers to reap the opportunities and address the challenges of the Industry 4.0 technologies? Which types of digital infrastructure is needed and how the investment for the Industry 4.0-compatible skills development can be raised? These questions are vital for future research agenda.

New research is needed to deeply understand the existing skills gaps and to offer policy solutions to bridge the skills for reaping the benefits of the Industry 4.0 for the labour markets. The research is also needed to analyze the types of skills required covering the basic, intermediate, and advanced technical skills for future workers in industrial sector including determining the duration of training, and channels and mode of training required such as training needs for displaced workers through formal training, training of new entrants through apprenticeship and on-the-job training, and training of future workers through formal education and training along with the need to reorient formal curriculum to enable future workers to enter the job markets without on-the-job training. There is need to understand the reskilling and upskilling requirements of workers displaced by the Industry 4.0-induced automation and the workers who remained in jobs but require new Industry 4.0-compatible skills to upgrade. The skills needs assessment of future workers should be done so that these new workers should be equipped with the Industry 4.0-compatible skills before leaving formal education or training and can enter labour market smoothly.

Like the garment manufacturing, deeper analysis of application of the Industry 4.0-compatible technological skills in services sector such as tourism is called for, to understand the impact on labor-market outcomes. New research is required to analyze how the acquisition of the Industry 4.0-compatible technological skills can help the displaced workers to reenter

into newly created jobs in service sector. The skills gaps in the Industry 4.0-compatible skills are also needed to be understand how analytical and non-routine tasks will increase in tourism services compared to routine tasks. Other relevant research questions to be probed in future research can focus on the following questions. What types of technical and complex problem solving, and critical thinking skills will be demanded in future? How social skills are demanded more in tourism sector compared to garment manufacturing? What can be the role of management skills vs social skills in increasing the employment potential in tourism sector?

References

Adeney, R. (2018). Structural change in the Australian economy. *Reserve Bank of Australia Bulletin*, 15 March, pp. 1–18.

African Development Bank Group, Asian Development Bank, European Bank for Reconstruction and Development, Inter-American Development Bank (2018). *The Future of Work: Regional Perspectives*. Washington, DC: AfDB, EBRD, IDB.

Aleksynska, M., & Muller, A. (2015). *Nothing more permanent than temporary? Understanding fixed-term contracts. Policy Brief, No. 6,* Geneva: International Labour Organization.

Aneesh, A. (2006). *Virtual Migration: The Programming of Globalization*. Durham, NC: Duke University Press.

Arntz, M., Gregory, T. & Zierahn, U. (2017). Revisiting the risk of automation. *Economics Letters*, 159(c), 157–160.

Artuc, E., & Caðlar, O. (2018). Transit migration: All roads lead to America. *The Economic Journal,* 128(612), F306–F334.

ADB. (2018). How technology affects jobs. *Asian Development Outlook 2018*. Manila: Asian Development Bank.

Asian Development Bank (2017a). *Reinventing Mutual Recognition Arrangements: Lessons from International Experiences and Insights for the ASEAN Region*. Manila: Asian Development Bank.

Asian Development Bank (2017b). *Asian Economic Integration Report 2017: The Era of Financial Interconnectedness*. Manila: Asian Development Bank.

Autor, D.H., & Dorn, D. (2013). The growth of low skill service jobs and the polarization of the U.S. labor market. *American Economic Review*, 103(5), 1553–1597.

Autor, D., & Salomons, A. (2018). *Is Automation Labor Share-Displacing? Productivity Growth, Employment, and the Labor Share*. Brookings Papers on Economic Activity. Washington, DC: The Brookings Institution.

Ayentimi, D,T., & Burgess, J. (2019). Is the fourth industrial revolution relevant to sub-Sahara Africa? *Technology Analysis and Strategic Management*, 31(6), 641–652.

Balaram, B., & Fabian, W.-S. (2018). *Thriving, Striving or Just about Surviving? Seven Portraits of Economic Security and Modern Work in the UK*. Future Work Centre and RSA (Royal Society for the encouragement of Arts, Manufactures and Commerce) Report, Australia and United Kingdom.

Baldwin, R. (2019). *The globotics upheaval. Globalization, robotics and the future of work*. New York: Oxford University Press.

Balliester, T., & Elsheikhi, A. (2018), The future of work: A literature review, ILO Research Department Working Paper, No. 29, March 2018. GenevaL International Labour Organization.

Bandura, R., & Hammond, M. (2018). *Developing Country Trends and Insights from Four Country Case Studies*. Vol. 2. Washington, DC: Center for Strategic and International Studies.

Bertulfo, D.J., Elisabetta, G., & Gaaitzen, D. V. (2019). *The Employment Effects of Technological Innovation and Participation in Global Value Chains: Evidence from Asia.* ADB Economics Working paper No. 572, Manila: Asian Development Bank.

Brougham, D., & Haar, J. (2017). Smart technology, artificial intelligence, robotics, and algorithms (STARA): Employees' perceptions of our future workplace. *Journal of Management & Organization*, 24(2), 239–257.

Chang, J.-H., & Phu, H. (2016). *ASEAN in Transformation: The Future of Jobs at Risk of Automation.* Geneva: International Labour Organization.

Davies, A., Fidler, D., & Gorbis, M. (2011). *Future work skills 2020*. Palo Alto: Institute for the Future.

De Ruyter, A., Brown, M., & Burgess, J. (2019). Gig work and the fourth industrial revolution: Conceptual and regulatory challenges. *Journal of International Affairs*, 72(1), 37–50.

EIU. (2018). The Automation Readiness Index: Who is ready for the coming wave of automation? London: Economist Intelligence Unit.

Frey, C., & Osborne, M. (2017). The future of employment: How susceptible are jobs to computerization. *Technological Forecasting & Social Change*, 114(C), 254–280.

Graham, M., Isis, H., & Vili, L. (2017). Digital labour and development: Impacts of global digital labour platforms and the gig economy on worker livelihoods. *European Review of Labour and Research*, 23(2), 135–162.

Hamel, J.-Y. (2009). *Information and Communication Technologies and Migration.* Human Development Research Paper No. 39, New York: United Nations Development Programme.

ILO. (2017). Global Employment Trends for Youth. Geneva: International Labour Organization.

Hirschi, A. (2018). The fourth industrial revolution: Issues and implications for career research and practice. *The Career Development Quarterly*, 66(3), 192–204.

ILO., & ADB. (2014). *ASEAN Community 2015: Managing Integration for Better Jobs and Shared Prosperity*. Bangkok: International Labour Organization and Asian Development Bank.

Jarrahi, M.H. (2018). Artificial intelligence and the future of work: Human-AI symbiosis in organizational decision making. *Business Horizons,* 61(4), 577–586.

Kobayashi, K., Khairuddin, A.R., Masahiko, F., & William, P.A. (2017). *Economic Integration and Regional Development: The ASEAN Economic Community*. New York: Routledge.

Lee, M., Yun, J.J., Pyka, A., Won, D., Kodama, F., Schiuma, G., Park, H. S., Jeon, J., Park, K.B., Jung, K.H., Yan, M.-R., Lee, S.Y., & Zhao, X. (2018). How to respond to the fourth industrial revolution, or the second information technology revolution? Dynamic new combinations between technology, market, and society through open innovation. *Journal of Open Innovation: Technology, Market, and Complexity*, 4(21), 1–24.

McKenzie, F. (2017). *The Fourth Industrial Revolution and International Migration.* Working Paper No. 5, Sydney: Lowy Institute for International Policy.

Maresova, P., Soukal, I., Svobodova, L., Hedvicakova, M., Javanmardi, E., Selamat, A., & Krejcar, O. (2018). Consequences of industry 4.0 in business and economics. *Economies*, 6(3). 1–14.

Messenger, J.C., & Gschwind, L. (2016).Three generations of telework: New ICTs and the (R)evolution from home office to virtual office. *New Technology, Work and Employment*, 31(3), 195–208.

Nagy, J., Oláh, J., Erdei, E., Máté, D., & Popp, J. (2018). The role and impact of industry 4.0 and the internet of things on the business strategy of the value chain: The case of Hungary. *Sustainability*, 10, 3491.

Nankervis, A., Connell, J., & Burgess, J. (2020). Comparisons and conclusions. In: Nankervis A,

Connell J and Burgess J (eds) *The Future of Work in Asia and Beyond: Technological Revolution or Evolution?* London: Routledge, pp. 201–215.

Park, S.-C. (2017). The fourth industrial revolution and implications for innovative cluster policies. *AI & SOCIETY*, 33(3), 433–445.

Prikshat, V., Montague, A., Connell, J., & Burgess, J. (2019). Australian graduates' work readiness–deficiencies, causes and potential solutions. *Higher Education, Skills and Work-Based Learning*, 10(2), 369–386.

Rainnie, A., & Dean, M. (2020). Industry 4.0 and the future of quality work in the global digital economy. *Labour & Industry*, 30(1), 16–33.

Ross, P., Ressia, S., & Sander, E. (2017). *Work in the 21st Century: How Do I Log oO?* Bingley: Emerald Publishing.

Sarvi, J., & Pillay, H. (2017). *Innovations in Knowledge and Learning: Postsecondary Education Reform to Support Employment and Inclusive Growth*. Manila: Asian Development Bank.

Schwab, K. (2016). *The Fourth Industrial Revolution*. Geneva: World Economic Forum.

Searle, R.H. (2019). Youth unemployment and underemployment: A global problem of our time. In Carter, A. (ed.) *Young People, Employment and Work Psychology: Interventions and Solutions*. London: Routledge.

Sima, V., Gheorghe, I.G., Subi´c, J., & Nancu, D. (2020). Influences of the Industry 4.0 Revolution on the Human Capital Development and Consumer Behavior: A Systematic Review. *Sustainability*, 12, 4035.

Stanford, J. (2017). The resurgence of gig work: Historical and theoretical perspectives. *Economic and Labour Relations Review*, 28(3), 382–401.

Stasiak-Betlejewska, R., Parv, L., & Gliñ, W. (2018). The influence of industry 4.0 on the enterprise competitiveness. *Multidisciplinary Aspects of Production Engineering*, 1(1), 641–648.

Stewart, I., & Debapratim, D., & Alex, C. (2015). *Technology and People: The Great Job-Creating Machine*. London: Deloitte LLP.

Stewart, A., & Stanford, J. (2017). Regulating work in the gig economy: What are the options? *The Economic and Labour Relations Review*, 28(3), 420–437.

Susskind, D. (2020). *A World without Work Technology, Automation, and How We Should Respond*. London: Penguin Books.

Teng, W., Ma, C., Pahlevansharif, S., & Turner, J. (2019). Graduate readiness for the employment market of the 4th industrial revolution. *Education + Training*, 61(5), 590–604.

Ulewicz, R., & Nový, F. (2017). Fatigue Resistance and Influence of Cutting Technology on the Mechanical Properties of Modern Steels Used in the Automotive Industry. *Procedia Engineering*, 192, 899–904.

Van Barneveld, K., Quinlan, M., Kriesler, P., *et al.* (2020). The COVID-19 pandemic: Lessons on building more equal and sustainable societies. *Economic and Labour Relations Review*, 31(2),

133–157.

Wobbe, W. (2016). Digitalisation of work and the social impact of the platform economy. In Durward, D., Blohm, I., & Leimeister, J. (Eds). *Principal forms of crowdsourcing and crowd work* (pp 13-36). Brussels: Foundation for European Progressive Studies.

WEF. (2016). *The future of jobs: employment, skills and workforce strategy for the fourth industrial revolution*. Geneva: World Economic Forum.

WEF. (2018). *Towards a reskilling revolution: industry-led action for the future of work*. Geneva: World Economic Forum.

WEF., & ADB. (2017). *ASEAN 4.0: What Does the Fourth Industrial Revolution Mean for Regional Economic Integration?* Geneva and Manila: World Economic Forum and Asian Development Bank.