Preparing Indian Youth for the Fourth Industrial Revolution
Radhika B

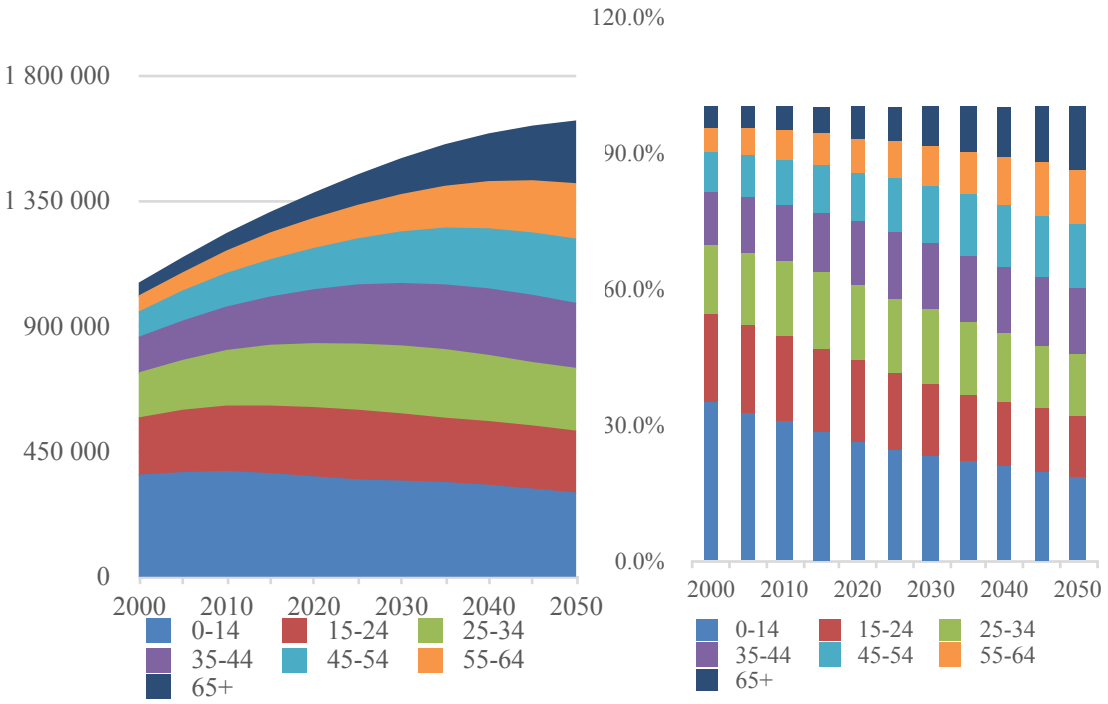
Abstract

In the 21st century, technological innovations that took decades to occur are being replaced in years, in some cases just months. These revolutionary technological breakthroughs present a unique opportunity for India to industrialise. With the right policy framework, India could use the democratic nature of technology to re-industrialize itself. This democratic nature of technology has allowed firms to overcome their country's legacy issues and become global leaders in various fields. This potential harnessed properly could help India industrialize and create global leaders from its soil. However, skilling, reskilling and upskilling are necessary conditions for actively allowing the participation of Indian youth in the sectors dominating the fourth industrial revolution. This paper analyses the Fourth Industrial Revolution, through crucial policy decisions taken by the Government of India, related to the skilling of youth.

I. Introduction

The term Industry 4.0, or the Fourth Industrial Revolution (4IR) has been playing a key part in policy discourse over the last few years. According to Schwab (2016), Industry 4.0 can be thought of as a fusion of technologies, blurring the traditional lines between physical, digital, and biological spaces. Examples of these technologies include the Internet of Things (IoT), Artificial Intelligence (AI), Machine Learning (ML), robotcs, 3D printing, amongst several others. As with any technological revolution, the productivity and efficiency benefits stand to be considerable. The countries best able to capitalise on these technologies can stand transformed in terms of their socio-economic outcomes. At the same time, India is amidst what many scholars have termed a demographic dividend (Chandrashekhar, Ghosh and Roychowdhury, 2006; Ladusingh and Narayana, 2012).This has led scholars to infer that this increase in working age population will translate into higher rates of growth. Figure 1 illustrates the swelling in India's working age population.

Figure 1: India's Age-Wise Population Projections (000s) and Shares (%)



Source: United Nations Population Prospects

As it can be seen, the working age population of India is likely to form a significant chunk of the population in the coming years. In terms of population shares, figure 2 illustrates. The share of the youth population (ages 15-24) will continue to constitute a significant chunk of the workforce in the coming years. However, while the potential for a demographic dividend has been accepted in discourse, questions have been raised around India's ability to realise such gains. The elevated levels of youth unemployment raise pertinent questions. Many claim that not enough jobs are being created. Others claim that employability is often a key issue, with graduates often found

lacking in basic skills. Poor outcomes in the education centre have been highlighted by several independent surveys. The issue of job creation is a larger macroeconomic question and lies beyond the scope of this paper.

The benefits of the impending 4IR will require preparing the workforce for such a transition. At the same time, policies enabling the growth of these industries will be needed. Government policies will no doubt play a crucial role in this regard. The purpose of this paper is multi-fold. First, it seeks to answer the question as to what the critical skills are needed for today's youth to succeed in the new world. Second, it offers a critical evaluation of government policies aimed at building a capable workforce and enabling environment for Industry 4.0 to thrive. Analysing expert insights along administrative datasets is a key contribution of this paper. Through this paper, the key skills required for preparing India's workforce for Industry 4.0 will be highlighted, along with policy prescriptions to enable such a transition. The paper is structured as follows: first, the literature is reviewed briefly. The next section presents the methodology and is followed by analysis of the results. Section V concludes and provides policy directions and avenues for future research.

II. Literature Review

Industry 4.0

Before delving into the skills necessary to harness Industry 4.0, it is instructive to understand how it has been defined and described by experts. Davis (2016) describes the Fourth Industrial Revolution as the advent of 'cyber-physical' systems, involving new capabilities for both man and machines. Xu, David and Kim (2018) summarise the opportunities being afforded by the 4IR as lower barriers for inventors, a greater role for AI, fusion of technologies, robotics and an increasingly connected life through IoT. Schwab (2016) states that the cost of communications and logistics will drop, opening up greater avenues for trade and economic growth. Yet, the challenge of inequality remains as Davis (2016) and Schwab (2016) have pointed out. Skill gaps could exacerbate inequalities, leading to a poorer quality of life for large proportion of populations. With climate change also expected to widen inequalities, especially in terms of quality of life, there remains a real risk of these economic and societal gains not being realised. It is in this context that skills become increasingly important and therefore investigated in this paper.

Future Skills

Armstrong, Parmelee, Santifort, Burley and Van Fleet (2018) provided some interesting insights through the Global Youth Survey. An interesting finding was that close to half of the respondents had not heard of the Fourth Industrial Revolution. Furthermore, close to 80% of the respondents felt the need to go outside the formal education system to obtain the skills they needed. A further third felt that their tertiary education did not prepare them well enough for their jobs. These findings imply the need to retool and repurpose education systems. Reviewing the skills of Indian workers, Mehta and Awasthi (2019) utilise survey data to classify the skill levels of Indian workers. Low-skilled and unskilled workers make up 86 percent of the total workers. The findings of this study imply that upskilling will be a real challenge for India. Caratozzolo, Piloto, Sirkis, and Correa (2021) address the issue of skills obsolescence. The authors identify two key forms of obsolescence that are likely to impact workers in the future. First is that of economic skill obsolescence. This means that the skills the workers possess are no longer in demand. Perspective obsolescence is the other. This means that works may possess obsolete beliefs about the workspace and future of work. The changing requirement of skills and the potential for automation of tasks implies that Industry 4.0 may make some jobs redundant, especially low-skill ones. Acemoglu and Restrepo (2020) explore the potential impact of AI on labour productivity and wages. They highlight two main channels through which AI will impact the economy. The first channel is the displacement effect. This means that several low-skill jobs can potentially be automated. However, they also hypothesise that along with the displacement effect, automation also generates a productivity effect. Higher premiums will be paid to workers that perform tasks that cannot be automated.

These findings, also provide an opportunity to raise prosperity. Building a future ready workforce would be key to this endeavour. This will require both, a change in the way education is imparted as well as evolving the skill requirements. The World Economic Forum highlighted the top 10 skills of 2025 in the Future of Jobs Report 2020, as the box below illustrates:

Analytical thinking and innovation
Active learning and learning strategies
Complex problem solving
Critical thinking and analysis

Creativity, originality and initiative
Leadership and social influence
Technology use, monitoring and control
Technology design and programming
Resilience, stress tolerance and flexibility
Reasoning, problem-solving and ideation.

Benprase (2018) reviews the response of education systems to earlier industrial revolutions, before touching on the 4IR. The author predicts that curriculums will need substantial changes, especially in the domains of science and technology. Computer science literacy is expected to demand significant premia according to the author. Interdisciplinary learning is another key aspect highlighted by Benprase. Caratozzolo et al. (2021) state that global citizenship skills, innovation and creativity skills, technology skills, and interpersonal skills as key. Furthermore, in terms of learning characteristics, they identify personalised and self-paced learning, accessible and inclusive learning, collaborative learning, and student driven learning as the key characteristics. Spottl and Windelband (2021) divide the essential skills between soft skills and technical skills. McKee and Gauch (2020) state that lifelong learning is likely to play a key role in the development of new skills. Teaching students how to learn will be key, according to the authors. Soft skills were also highlighted by the authors as essential. Enabling digital learning through dedicated spaces and modules was another key recommendation. Eberhard et al. (2018) in their semi-structured interview of experts of university professors in Germany reported that social skills were perceived to be the most important by them in the skill portfolio of university students. This was followed by cognitive skills, personal skills, process skills, and system skills rounding out the top 5. Studying the Indian manufacturing context, Chenoy, Mishra and Shukla (2019), report similar skill requirements to the above studies. Sudan (2021) suggests a 4IR ready model for skill development in Asia. Foundational skills, such as digital literacy, time management form one component in the model. Soft skills, technical skills and entrepreneurship skills were the other components of the model proposed by the author.

Government of India Initiatives

A brief review of some select Government of India (GoI) initiatives is instructive to understand the evolving skills ecosystem and the overall policy thrust towards Industry 4.0. The Digital India Mission was launched in 2015, as an overarching mission towards digitising the Indian economy. Through this mission, a robust digital backbone can be created that will allow 4IR technologies to thrive in India. Examples of initiatives under this mission include the BharatNet project, which seeks to provide high-speed broadband connectivity to India's villages. India's rapidly expanding digital payments space is another pertinent example. Recognising the need to upskill India's workers, the National Skill Development Mission was also launched in 2015. Additional data highlights that in India only 2.3 percent of the Indian workforce underwent formal training, as compared to 75 percent in Germany, 80 percent in Japan and 96 percent in South Korea (GoI, 2015). The target set in 2015 was to train 300 million people by 2022. The missions on skill development and those in manufacturing, such as Make in India complement each other. Initiatives such as Make in India would raise the demand for trained workers in the manufacturing space and various skill development schemes would feed into them. Several other line ministries/departments, for example in domains such as agriculture, heavy industry, and tourism. Training has not been limited to skill development missions. Apprenticeships have also been revamped. Both the Ministry of Education and the Ministry of Skill Development run apprenticeship schemes of their own. The National Institution for Transforming India (NITI) Aayog, the Government of India's premier think-tank has also been actively working towards developing an ecosystem for Industry 4.0 to thrive. Discussion papers on AI and blockchain have been an attempt in this direction. Apart from skill development and vocational training, an ambitious restructuring of India's education system has been proposed in the New Education Policy released in 2020. Innovation and entrepreneurship is being promoted at a young age through the Atal Innovation Mission, which is opening tinkering labs in schools and incubation centres in colleges. The Start Up India Mission has been well received, and has played a part in establishing a dynamic startup ecosystem in India. To boost manufacturing, initiatives such as Make in India and Production Linked Incentive (PLI) schemes have been launched.

III. Methodology

This study is qualitative in nature. It combines desk research along with semi-structured expert interviews to address the research questions at hand. There are several advantages to using semi-structured interviews. First, since this study is attempting to assess future skills and government initiatives, there is a need to ask probing, open-ended questions to draw inferences. According to Adams (2015), this need is best served by semi-structured interviews. This method also sets this study apart. The experts interviewed range from policy professionals, industry experts and academics. The experts are particularly suited to provide actionable policy and research insights. The interview guide was prepared following the comprehensive review carried out by Kallio, Pietilä, Johnson and Kangasniemi (2016). The analysis has been conducted following the procedure laid out by Schmidt (2004). At the same time, administrative data available from various Government of India initiatives has been utilised to complement the analysis of the interviews. The semi-structured interview contained prompts around generating an understanding of what skills the participants viewed as essential in readying the workforce for Industry 4.0. To generate relevant insights, the participants were selected based on their knowledge of Industry 4.0. Therefore, the interview intentionally presupposed knowledge on Industry 4.0. The second part of the structured interview focused on eliciting responses on how the skill delivery ecosystem in India can be improved. The responses were then analysed to derive policy directions for improving the skill delivery ecosystem in India.

IV. Results & Analysis

Skills Required

Table 1 summarises the key findings from the expert interviews about the skill requirements of the future. Almost all participants highlighted the need for building technological skills from a young age. Introducing coding at a young age was prescribed by several experts. The rationale given by one participant was that knowing a coding language, or several would be crucial in the future. This was justified by the cross-cutting potential applications of Industry 4.0. One pertinent example was given that now, the requirement of big data analytics would be increasingly important in public policy, given the vast amount of data being generated. One respondent likened the need to develop Industry 4.0 skills to the large-scale introduction of computers. For instance, they stated that many white-collar workers possess a working knowledge of tools such as Microsoft Word, Excel, and PowerPoint by the time they enter the job market. In the future, educational systems should be suitably modified so that by the time the youth enter the job market, they possess working knowledge of a coding language, which allow them to build on their skills. Examples cited included data visualisation software such as Tableau, Geographic Information Systems (GIS), and statistical software such as R.

Table 1: Key Skills Identified by Interviews

	Sub-Group	**Examples**
1	Technological Skills	Coding, big data analytics, project management, product design, specialised software
2	Cognitive Skills	Critical thinking, learning skills, problem solving, creative thinking
3	Soft Skills	Interpersonal skills, teamwork, negotiation, persuasion, leadership

Source: Author analysis

Cognitive and soft skills emerged as another sub-group emphasised upon by the interviewees. These can perhaps be best characterised by the 4 C's of 21st century skills, as termed in the popular press. These are communication, creativity, collaboration, and critical thinking. The results from the interviews are largely in consensus with the literature reviewed on identifying skills necessary for the workforce to capitalise on Industry 4.0. The emphasis on technology skills is given more importance in the interview responses than in the literature. This is perhaps an outcome of the small sample size, and a larger sample study will be needed to further analyse this trend. The emphasis on cognitive skills, further reiterates the ideology of required skills.

Improving Skills Ecosystem

Public-private partnerships (PPPs) in designing, skilling and education curriculums was an oft repeated theme. Several respondents alluded to the need of regularly updating curriculums, keeping in mind the needs of industry. This view has also been echoed in the literature. One respondent pointed towards the partnership between India's Ministry of Electronics and Information Technology (MeITY) and National Association of Software and Service Companies (NASSCOM) called the Future Skills Initiative as an apt example. Here, industry is taking the lead in developing a skilling ecosystem. Training is imparted in technologies such as AI, IoT, cloud computing and big data, amongst others. Another respondent highlighted the need for a similar

initiative in the manufacturing space. They stated that manufacturing is likely going to undergo a radical change in the coming years. Robotics and automation will play a crucial role and skills will need to be developed to leverage these technologies.

Expanding apprenticeships was another emerging theme. Some participants mentioned the National Apprenticeship Training Scheme (NATS) and the National Apprenticeships Promotion Scheme (NAPS), both run by the GoI. However, it was highlighted that the scope of both the NATS and NAPS could well be expanded, both by increasing the stipend paid to apprentices and increasing the target of apprentices being trained. For instance, in 2021, the NATS had been approved with an outlay of Rs. 3,000 crores (USD 400 mn), with a target to train 900,000 apprentices by 2026. (Government of India, 2021). The rationale given by the respondents to promote apprenticeships was that it would promote 'on-the-job' training for the youth. Respondents also highlighted a need to converge efforts in apprenticeship programmes. Reorienting the Skill India Mission was also touched upon by the respondents. Some were of the view that the Sector Skill Councils were too many in number and often overlapped with each other. One respondent cited an op-ed in the popular press which stated that India had four skill councils in manufacturing, whereas the global best practice was to just have one. The myriad of skill development programmes was also highlighted by a few participants. They were of the view that apart from the Ministry of Skill Development, several other line ministries/departments ran their own skill development initiatives, and that these efforts needed to be converged.

In terms of changes to educational curriculum and teaching methods, all participants pointed towards the New Education Policy (NEP) released by the Ministry of Education in 2020. The participants agreed that the policy was forward looking. However, some participants highlighted the differing pace at which India's various constituent states would be able to adopt the NEP. They pointed towards the large infrastructure deficit in several states, that could slow down the pace of adoption.

Status of Formal Training in India

Results from India's large scale Periodic Labour Force Surveys (PLFS) seem to indicate a growing presence of formal vocational/technical training as Table x indicates. The PLFS has been instituted from 2017-18, providing annual and quarterly estimates of employment. This is a welcome change from the earlier practice of quinquennial surveys. However, since the sampling design differs from the earlier surveys, the results from the two are not necessarily comparable. From 2.5 percent of all those in the 15-29 category receiving formal training in 2017-18, the share has gone to 4.1 percent. An improvement, however, the proportion remains low. The proportion of males receiving formal training remained higher than females, with both exhibiting an improvement. The urban-rural divide in India was evident, as urban areas showed higher proportions of formal training than rural areas.

Table 2: Percentage of Formal Training

	Total		**Male**		**Female**	
	15-29	**15-59**	**15-29**	**15-59**	**15-29**	**15-59**
2017-18	2.5	2.0	2.8	2.3	2.2	1.7
2018-19	2.8	2.4	3.2	2.8	2.5	2.0
2019-20	4.1	3.2	4.3	3.5	3.8	2.9

Source: Periodic Labour Force Survey Report 2019-20, Ministry of Statistics and Programme Implementation

The results from the survey seem to indicate a growing trend towards formal vocational/technical training. The PLFS reports also provide insights into the fields in which formal training is taking place. Table 3 shows the percentage distribution by field of training for persons aged 15-59. The top five fields are displayed. IT and ITeS are the clear leaders, with a quarter of all formal training being conducted in this field in 2019-20. The textiles sector was the second most popular field with females dominating in the field. Contrastingly, in electronics sector, a higher proportion of males received training compared to females. The same was true for mechanical engineering and strategic manufacturing. Health care and life sciences rounded off the top 5 fields of training in 2019-20, with more females being trained than males in this field.

Table 3: Percentage Distribution of those who Received Formal Training by Field of Training in 2019-20 (Top 5)

	Percentage Distribution		
Field of Training	**Male**	**Female**	**Total**
IT and ITeS	27.8	25.4	26.7
Textiles, Handlooms and Apparels	1.2	22.5	10.7
Electrical, Power and Electronics	15.2	2.2	9.4
Mechanical engineering – capital goods, strategic manufacturing	8.7	0.6	5.1
Healthcare and Life Sciences	3.4	6.4	4.7

Source: Periodic Labour Force Survey 2019-20, Ministry of Statistics and Programme Implementation

These finding imply that India is on the right path of skill development as the top 5 training areas show. The high share of IT and ITeS can be leveraged by introducing Industry 4.0 in training modules and promoting coding languages from a young age. Similarly, the manufacturing field should seek to incorporate technologies that will be key to factories of the future. The focus on electronics training is likely to reap dividends through the thrust on electronics manufacturing given by the Government of India. Soft skills were highlighted both in the literature and interviews. Soft skills training has been embedded into various skill development courses offered by the GoI. This would help in overcoming the skill and learning deficit, enabling lifelong learning and self-learning.

V. Conclusion and Policy Implications

This paper has attempted to uncover the skill requirements for Industry 4.0 and to suggest ways to better prepare the Indian workforce for the challenges to come. India is amidst a phase of a bulging working age population. Industry 4.0 affords India the opportunity to leapfrog the technological ladder, however, this will not be without challenges. Skilling and education will be central to these efforts. With India already in a skill deficit in times of a bulging working age population, the skill deficit has potential to derail India's demographic dividend. The findings of Mehta and Awasthi (2019) point towards the fact that many of India's low skill jobs stand to be automated. This further reiterates the need to upskill India' workforce.

This study is a preliminary investigation into the skill requirements of Industry 4.0 in India. Further avenues for research include use of large-scale representative surveys to assess the demand side of the skills ecosystem. A limitation of the paper is that it looks at the supply of skill development programmes. Future studies may consider surveys, interviews and other appropriate research methods to analyse what skills the youth consider necessary and how they would want to learn such skills. Future research may also focus on the ancillary skills that may be needed in the Industry 4.0 transition. While direct skills training and education will lead to the development of high-skill workers, research may focus on the ancillary jobs that can be created. For instance, the advent of eCommerce has led to the creation of several jobs in the last-mile delivery space. The adoption of Industry 4.0 will create direct jobs, but the skill requirements of the ancillary jobs can also be investigated. Soft and cognitive skills also emerged as crucial from the literature and interviews. Currently, skill development efforts in India include the development of soft skills as part of existing training modules. Future research may also focus on studying the viability of introducing dedicated courses in building soft and cognitive skills. Modules on learning, for instance, may open up avenues for lifelong learning, which again will be crucial to harnessing the potential of Industry 4.0.

Reference List

Acemoglu, D., & Restrepo, P. (2018). *Artificial intelligence, automation, and work.* In The economics of artificial intelligence: An agenda (pp. 197-236). University of Chicago Press.

Adams, W. C. (2015). Conducting semi-structured interviews. *Handbook of practical program evaluation*, *4*, 492-505.

Armstrong, K., Parmelee, L., Santifort, S., Burley, J., & Van Fleet, J. W. (2018). Preparing tomorrow's workforce for the Fourth industrial revolution for business: A framework for action. *Deloitte & The Global Business Coalition for Education*.

Caratozzolo, P., Sirkis, G., Piloto, C., & Correa, M. (2020, November). Skills Obsolescence and Education Global Risks in the Fourth Industrial Revolution. In 2020 IFEES World Engineering Education Forum-Global Engineering Deans Council (WEEF-GEDC) (pp. 1-5). IEEE.

Chandrasekhar, C. P., Ghosh, J., & Roychowdhury, A. (2006). The'demographic dividend' and young India's economic future. *Economic and Political Weekly*, 5055-5064.

Chenoy, D., Mishra, S., Ghosh, and Shukla, S.N. (2019). *Skill development for accelerating the manufacturing sector: the role of 'new-age' skills for 'Make in India'*. International Journal of Training Research, 17:sup1, 112-130, DOI: 10.1080/14480220.2019.1639294

Davis, N. (2016, January). What is the fourth industrial revolution. In *World Economic Forum* (Vol. 19).

Eberhard, B., Podio, M., Alonso, A. P., Radovica, E., Avotina, L., Peiseniece, L., Sendon, M.C., Lozano, A.G., & Solé-Pla, J. (2017). Smart work: The transformation of the labour market due to the fourth industrial revolution (I4. 0). *International Journal of Business & Economic Sciences Applied Research*, *10*(3).

Kallio, H., Pietilä, A. M., Johnson, M., & Kangasniemi, M. (2016). Systematic methodological review: developing a framework for a qualitative semi-structured interview guide. *Journal of advanced nursing*, *72*(12), 2954-2965.

Ladusingh, L., & Narayana, M. R. (2012). Demographic dividends for India: evidence and implications based on national transfer accounts. In *Aging, Economic Growth, and Old-Age Security in Asia*. Edward Elgar Publishing.

McKee, S., & Gauch, D. (2020). Implications of Industry 4.0 on Skills Development. In *Anticipating and Preparing for Emerging Skills and Jobs* (pp. 279-288). Springer, Singapore.

Mehta, B. S., & Awasthi, I. C. (2019). Industry 4.0 and future of work in India. *FIIB Business Review*, *8*(1), 9-16.

Penprase, B. E. (2018). The fourth industrial revolution and higher education. *Higher education in the era of the fourth industrial revolution*, *10*, 978-981.

Schmidt, C. (2004). The analysis of semi-structured interviews. *A companion to qualitative research*, *253*(41), 258.

Schwab, K. (2017). *The fourth industrial revolution*. Currency.

Spöttl, G., & Windelband, L. (2021). The 4th industrial revolution–its impact on vocational skills. *Journal of Education and Work*, *34*(1), 29-52.

World Economic Forum (2020). The Future of Jobs Report.

Xu, M., David, J. M., & Kim, S. H. (2018). The fourth industrial revolution: Opportunities and challenges. *International journal of financial research*, *9*(2), 90-95.