Indian Institute of Space Science and Technology

Thiruvananthapuram

B Tech Economics Project

A

Study Report on

Technological Progress v/s Employment

Submitted by

B Tech AEROSPACE 2020 batch

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October 2021

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Declaration

This project report titled “Technological progress v/s Unemployment” is a presentation of our original research work. Wherever contributions of others are involved, every effort is made to indicate this clearly, with due respect to the literature, and acknowledgement of collaborative research and discussions.

Date: 29th October 2021.

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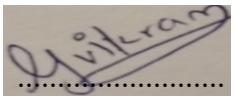
1.	Vikram Ganesh	
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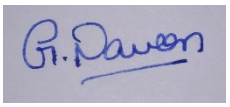
3.	Naveen G	

Acknowledgement

At the outset, we would like to express our gratitude to Dr Shaijumon, Associate Professor of Economics at the Indian Institute of Space Science and Technology for giving us this highly informative project on the effect of technology on employment.

We are also extremely thankful for all the sources that provided us with information that was crucial for the completion of this project. Our knowledge of the subject has increased tremendously and this experience will stay with us for a lifetime.

Abstract

This paper investigates the effect of technology on employment, whether it has a positive or negative impact. Many technological advancements have led to unemployment all over the world and created some serious repercussions in society. The effects depend on the duration and group of study. This paper also shows various data, reviews different articles and applies models on technological employment/unemployment to conclude that technology causes job polarization. Important skills required for employment are also investigated on an empirical basis. Skills relevant to the upcoming digital world are predicted to be in high demand. The paper investigates the effects of technological growth on the gender gap in employment and concludes that the growth of technology has increased women's participation in the labour force and eventually it reduced the gender gap by increasing job opportunities for women.

Keywords

Technology, employment, unemployment, skills, jobs, long-term, short-term.

Contents

Technological Progress v/s Employment

Introduction

In our everyday life, we come across various technologies and become awestruck by their work and efficiency. But still, we deeply get a thought like, “What happened to the people who were doing these works before? Is there any possibility that we may become a victim of unemployment because of increasing innovations in technology?” and many more.

Technological unemployment refers to the loss of jobs caused by technical change. Technological unemployment is one of the important problems prevailing in society, which needs to be discussed in each country.

Many business firms, to increase their profit, pave their way towards adopting new technologies, thus leading to unemployment. A big Dutch bank has replaced around 5800 people with machines, for 2 billion dollars[1]. According to the World Bank, automation threatens 69 per cent of the jobs in India, while 77 per cent in China. According to research firm Gartner, more jobs will be created than lost by automation. The firm stated that 1.8 million jobs will be eliminated by 2020, but 2.3 million new jobs will be created by then.

Similar situations prevail in India too. The rapid advances in the capacity of computing technology are raising the spectre of technological unemployment in the world. Also, as Artificial Intelligence helps in doing many complicated tasks quickly and efficiently, the possibilities of many jobs getting taken over by AI have increased. Though technologies have helped in developing our country’s economy, it has been found that the amount of people getting displaced because of technological advancement is increasing at a significant rate. And because of this, many people are losing their livelihood.

In this report, we are going to discuss the problem of unemployment due to technology, as it prevails in the entire world and has some serious repercussions on society, with the help of data, graphs and models from different sources. For this report, we have taken 3 main objectives and studied them. They are

[1] "Dutch bank ING is replacing 5800 people with machines, at a cost of ...." 4 Oct. 2016, https://qz.com/799816/dutch-bank-ing-is-replacing-5800-people-with-machines-at-a-cost-of-2-billion/. Accessed 24 Oct. 2021.

1. To study the long term and short-term effects of technology on employment.
2. To find out the demand for various skills and jobs due to technological progress.
3. To study the impact of technology on women unemployment.

Research Questions

a. Does the unemployment rate differ in the long run and short run of technological growth?

b. Will the demand for skills for the same job change in future?

c. Does technological growth have any specific impact on women's unemployment?

Literature review

Due to technological development, it is increasingly easier to apply for and does jobs than ever. This increases the opportunities for many but also is a double-edged sword as the competition inevitably increases. The need for personal contact has decreased leading to a tremendous increase in productivity[2].

Rifkin says that the skills of some people may not be useful in the new society and these people may not have the skills needed for the new employers, as a result, this can cause unemployment[3]. David and Wessel believe that because of the high mobility of IT capital and its inherently knowledge-based nature, it may be possible for the lower-income countries to jump from some stages in traditional economic development, by investments in their human resources (David & Wessel, 1998).

According to Gartner[4] categorization, the development of IT infrastructure needs a good improvement in 4 main areas:

1. Software: which mostly needs a highly educated workforce.
2. Hardware: needs both well-educated people in design and unskilled workers in the production lines and factories.
3. Telecommunication Structure: This will create many jobs in developing countries for unskilled workers (digging grounds) and skilled workers (design the network) However, for a developed country in which normally these networks exist and there is no need to have a massive development but to improve it constantly, the effect on the job market is negligible.
4. IT services: maintenance of hardware, software and providing content are some types of IT services. The main requirement for a society using IT is to have information content once they have already prepared their infrastructure. Again, for a developed country in which most organizations already made all their data available electronically, thus will not increase jobs significantly but for a developing country, this will result in a sharp increase of job opportunities (converting to e-data etc) for a limited time before they get to a steady-state.

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[2] Online shopping, search engines are a boon for users.
[3] J. Rifkin " The End of Work - The Decline of the Global Labor Force and the Dawn of the Post-Market Era", Tarcher/Putnam, New York, 1995.
[4] Gartner | Delivering Actionable, Objective Insight to Executives and Their Teams

Kulsoom, Mohammed and Sadegh observe that employment rate and e-readiness[5] are inversely related to each other. This concludes that the more ready the countries are in terms of e-readiness the lesser the ill effects of technology on employment. (Shahkooh et al., 2008). Skills mismatch, technological monopoly, unequal tax systems are some of the main causes[6] of technological unemployment. Inevitably, inequality between people increases, consumption decreases due to lack of financial security which in turn may lead to the collapse of the whole economy. (Lima et al., 2021). Income inequality is increasing at the same time as the costs of "big data" storage are falling. As jobs are being destroyed in manufacturing and parts of services sectors, employment in both low- and high-skilled occupations has risen. There is evident job polarization due to technological advancements. (International Labour Organisation, 2018)

Otekhile & Zeleny explain the importance as well as the problems caused by the increasing usage of SSTs[7]. Many business firms, to stay in the competition, pave their way towards SSTs as they are less expensive and increase productivity to higher levels. Also, as consumers, we expect the services to be user friendly and at fair prices, which is mostly satisfied by SSTs. There's no doubt that millions of jobs are lost because of technological advancements. They feel that there is a possibility of reducing technological unemployment and it is the emergence of a new sector, where the workers who were displaced by the other sectors can be given a job. (Otekhile & Zeleny, 2016)

Marchant et al., (2014, 26-44), say that unemployment may also become a burden to the economy as the unemployed may not be able to contribute to the economy as consumers. Also, the lack of employment opportunities for young people, who don't have much experience, may lead to social disruption. So, it becomes essential for updating the policies along with the technological changes. Employment can be protected by slowing down technological innovations, but they have not been successful, as it reduces the economic growth and development of the country. Also, due to the demand and benefits of technology, they are

[5] Please see Appendix A

[6] Please see Appendix B for more information on causes of technological unemployment.

[7] One of the major reasons for technological unemployment is self-service technologies (SSTs). In India, Fastags have been implemented recently, and because of that many employees have lost their jobs. Union Road Transport Minister Nitin Gadkari said that Fastags would help save around 20000 crore rupees annually, as it would reduce the traffic rate in toll plazas. According to many news agencies, Fastags have been much easier, faster and user friendly and helped in time management of the consumers. Also, they would help in developing the economy. But yes, around 75% of the employees have lost their jobs.

produced and commercialised rapidly. Another way of protecting employment is by sharing work. People can be employed to do the same work, but with fewer working hours, so that a large number of persons can be employed and at the same time, they can spend more time with their family and leisure. But still, more employees require extra training, monitoring and evaluation costs and also, the continuity of work can be affected. The creation of new jobs has become a need of the hour. Government can create new jobs, give incentives to private companies in the form of tax credits to hire more workers and conduct Job Guarantee Programs (JGP). Though they are slightly expensive, the results we get would be valuable. Government should introduce policies that guarantee that each citizen would get a minimum income. They also feel like, in the fast-changing world, it becomes important for people to adapt themselves to the changing technology. Therefore, the education provided must be life-long, so that they can develop new skills. The education system must be updated in recent intervals and more practical knowledge about society and the world must be imparted.

Mabry et al. (1986) speaks about the short-run and long-run effects of technological advancement in unemployment and denies the Phillips curve which is a negatively sloped curve between wage-rate inflation and unemployment rates hypothesized by Phillip in 1950 for a long run trade-off. They refer to Santomero and Seater (1978) for this statement. They argue that returning to a hunting-and-gathering economy would assure full employment, but this only reduces population levels, lowers total employment, and subsistence living standards. Under the short-run effects, they speak about the Rent-seeking effect of the short-run. And states most of the persons who believe in restricting growth in technology for the sake of avoiding unemployment have their base of thought from short-term distributional effects of technology growth. They also their points on Depreciation-of-Human-Capital portray the reasons for which the capitalists are in fear of investing in humans as investing in human capital would depreciate more compared to an investment in a technological improvement which not only increases the output but can also be capable of lowering the production costs.

Dennis Chamot argues that modern technologies have tremendous applications in every kind of organization at every level. He says “We are faced with nothing less than the redefinition of work, and in the process, many positions will be eliminated”. He concludes that the full benefits of technology on employment can be unravelled by the combined efforts of the governments, business and engineering communities, labour, and the public. (National Academy of Engineering & Chamot, 1983, 24-27). The government must find ways of raising funds to

support the educational sector. Online coaching, setting the required infrastructure etc for effective training would help develop technical skills and reach out to a wide variety of people through the platform of the internet. The ill-effects of technology could be countered in the next 20 years following this plan. (Agbozo et al., 2016)

Conclusion

In conclusion, we reviewed different views on the effect of IT on unemployment. These views are controversial, but all could be right according to different conditions. Not all countries have the same situation in terms of telecom infrastructure, nor have the same population structure. IT can worsen the unemployment situation in developed countries as some experts forecast, but at the same time, it can have a very positive effect in developing countries. Also, we reviewed the effect of increasing usage of SSTs and how they could affect the livelihood of many people. There are ways to reduce unemployment in the world, like through the implementation of policies, but they have some short- and long-term consequences too.

Research gap

The problem of skills requirement/ matching skillset is central to employment. Also, long term and short-term aspects of the impact of technology on employment are vital for understanding and planning the required countermeasures against a possible ill-fated future. The effect of technology on the gender gap in employment is also to be understood.

The effect of automation is predicted to be profound on society in general as we are on the verge of the fourth industrial revolution. Once long term and short-term effects of technologies and leading skills are sought after by employees, proper efforts can be put into policymaking to improve the labour market for both employers and employees.

Research problem

Technological progress is accompanied by short term unemployment but in the long term employment rates increase. They affect the gender ratio in a positive way. Every time technological progress occurs there is a shift in skill requirements. The knowledge of the effects of technological growth on skill requirements, gender gap is essential.

Research objectives

a) To identify the long term and short-term effects of technology on employment.
b) To identify the skills required for employment during the Fourth Industrial Revolution.
c) To identify the Impact of Technology in Women Unemployment

Objective-1

Long term and short-term effects of technology on employment

Introduction

For a long time, business firms have been using technology at a tremendous rate. The United States is one of the most powerful countries in the world, which has seen many powerful people throughout their history, preaching the importance of working hard and staying busy. But still, many people find themselves unemployed there. In the past 20 years, the number of manufacturing industries in the US has dropped by almost 30%, i.e., by around 5.5 million jobs. Also, according to statistics, the percentage of prime-age men who are unemployed and aren't looking for any job has doubled since the 1970s[8].

Null Hypothesis

There is no difference in the long term and short term effects of technology on employment.

Alternate Hypothesis

Long term effect of technology on the employment rate is positively sloped while the short term effect of technology on employment is negatively sloped.

Methodology and Data Sources

Visual models are used to conclude the effects of technology on employment Graphs and figures have been collected from various sources to supplement the findings. Drawing on the methodology used by Ugur et al.(2018, 7-8), using the derived labour demand model, conclusions have been made. Information and figures were collected from Berkeley Economic Review to draw further conclusions.

i) The derived demand labour demand model

Theoretical predictions made from the DLDM are:

[8] Berkeley Economic Review, https://www.econreview.berkeley.edu,

The higher the firm's market power, the less likely it is to observe a positive relationship between technological innovation and employment. Firms with high market power tend to set prices above the marginal cost, thereby decreasing demand and hence demand labour.

Higher product market regulation tends to have negative effects on employment due to technology due to lesser flexibility and competitive labour and product market respectively.

The higher the rate of substitution between capital and labour is, the more likely it is to observe a negative relationship between technological innovation and employment.

Process innovation[9] is more likely to reduce labour demand while Product innovation[10] is more likely to have an opposite effect.

ii) Graph and data-driven analysis

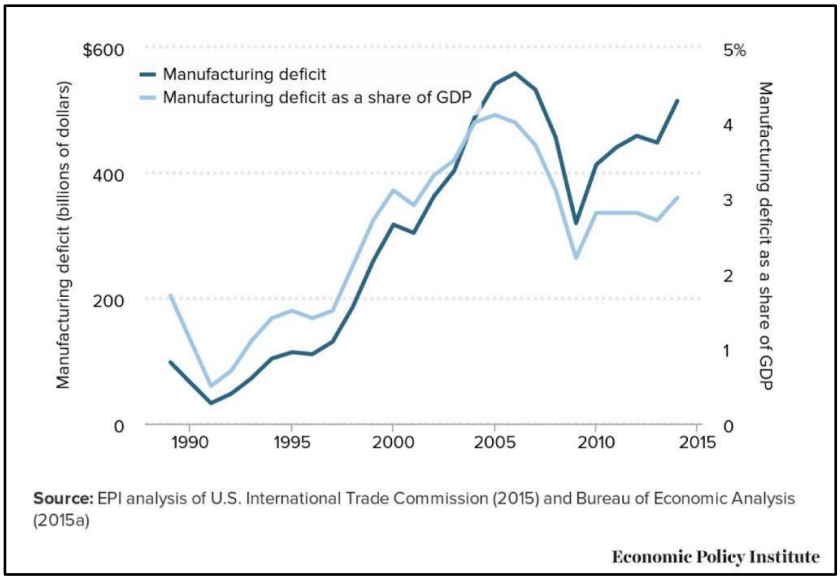


Figure 1:US manufacturing goods trade deficit 1989-2014

From the above graph[11], we can see that the trade deficit has been increasing at a rapid pace since the 1990s because of the use of technology, which has ultimately led to the loss of manufacturing jobs. If we take the graph given below, we can see that productivity and

[9] Changing manual labour to automatic machines that don't require labour. E.x Automation robots
[10] This leads to a requirement of more labour that is skilled in that product domain.
[11] https://www.econreview.berkeley.edu

employment are increasing steadily, which is a good thing to see. But, at the same time, we can see that productivity goes on increasing while employment starts decelerating from 2010. It directly shows the effect of technology on employment.

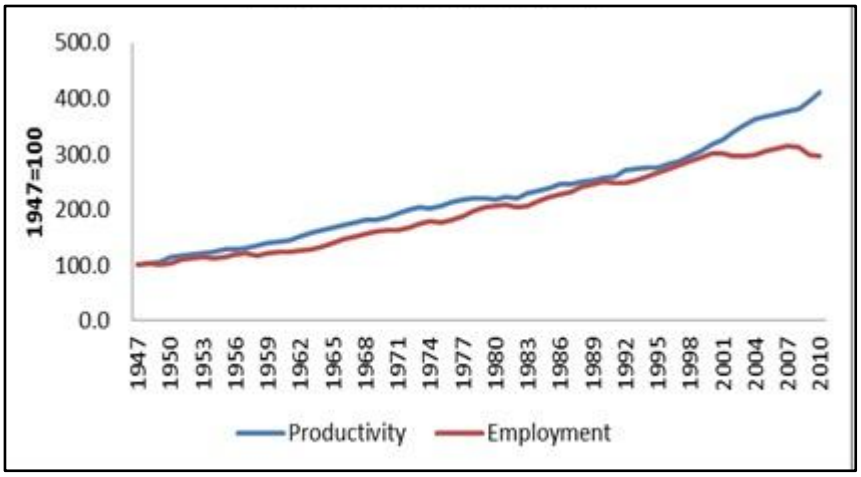


Figure 2:Rate of change in employment and productivity since 1947

Let us now talk about India. Vashisht, 2017, argues that since the 1980s, when the Indian economy opened up to foreign trade, many Indian manufacturers opted out to invest in new technologies over labour. And because of that, the demand for high-skill increased significantly and led to a polarization of job opportunities within the manufacturing sector.

Since the 1990s, as foreign trade started to glorify in our country, more diffusion of foreign technology started to take place. This can be seen as evident from the increase in the ratio of Imported capital and net capital, which shows a tremendous increase from 1990-91 to 2011-12. Consequently, more investment in ICT capital happened, which directly captures the increasing use of technology by business firms.

Figure 3:Information about change in employment

Among the three tiers – low-wage jobs, mid-wage jobs and high-wage jobs – workers in the middle tier are being squeezed.

High wage jobs require skilled people. This is fairly obvious due to the technological revolution that is happening. On the other hand, more people are required for low-waged (skilled) jobs that are nearly impossible to automate. Autor says computer technologies are changing the types of jobs available, and those changes "are not always for the good."

Jobs that are the most vulnerable to automation and technological growth, in general, are the routine ones. At least since the 1980s, he says, computers have increasingly taken over such tasks as bookkeeping, clerical work, and repetitive production jobs in manufacturing—all of which typically provided middle-class pay.

Tasks have shifted from mid-wage jobs to low and high wage jobs at the rate of 4:1. As a result, there has been a sort of polarization effect in the employment and wages of the jobs (see the figure).

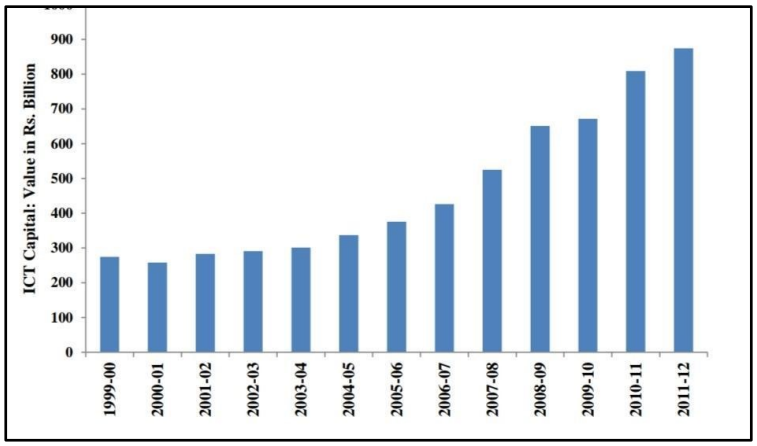


Figure 4:Change in value of ICT capital stock over the years

From this graph, we can see that the value of ICT capital stock increased incredibly in a span of 6-7 years between 2005 and 2012, while it was remaining almost the same in the 90s and early 2000s. While foreign trade was slowly coming up, employment growth recovered in the first half of the 1990s at an annual rate of 3.73%. But, after that, it started to come down from 1996-97 at an annual rate of 1.73%. Kannan and Raveendran (2009) say that in the period between 1980-81 and 2003-04, the manufacturing value-added grew at an annual rate of 7.5% while the employment growth was just 0.76%.

Many researchers warn that robots may take over 70% of our jobs in the next 10-20 years in the world. From the above graph, we can see that there's a probability of about 0.99 for the jobs of telemarketers to be taken over by robots. In the long run, most of the jobs will be taken

over by robots. Unless a country refuses to trade with other nations and thereby lower its overall standard of living, it will experience short-run unemployment problems when its industries are forced by the competition to use robots.

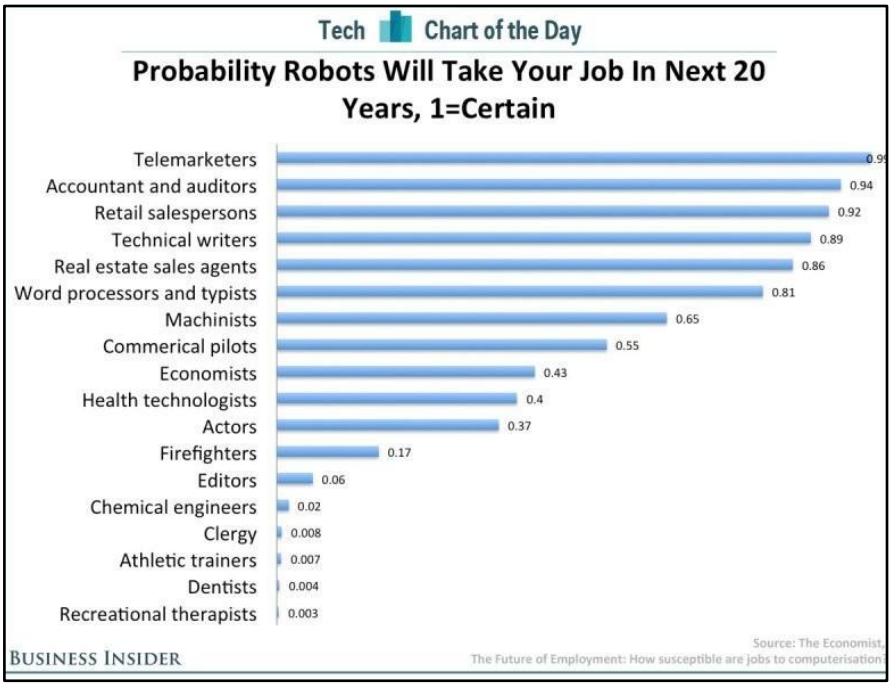


Figure 5:Probability of jobs getting automated in future

It is the only technological improvement that enables employees to take place at higher-than-subsistence levels of output. Returning to a hunting-and-gathering economy would assure full employment, but only at reduced population levels, lower total employment, and subsistence living standards. Arresting technological advancement now, while the population continues to grow, would also assure full employment only at ever-declining standards of living.

A long-run economic goal in any society is the advancement of its standard of living.
Human wants are unlimited. It is the explanation for the fact that we have not already run out of job opportunities, given the tremendous improvements in efficiency that have taken place since the agricultural revolution. It also goes with the Luddite Fallacy argument which says that technological progress does not decrease the overall unemployment but only changes the composition of the workforce[12]. Because of unlimited wants, people in the future will still be

[12] Luddites were a group of English textile workers who lived during the first industrial revolution period. They feared that machines would destroy their jobs and livelihoods. The machines were more productive

fully employed to the extent they choose to be, even if there is a headlong rush to automate and mechanize industry in this decade and beyond.

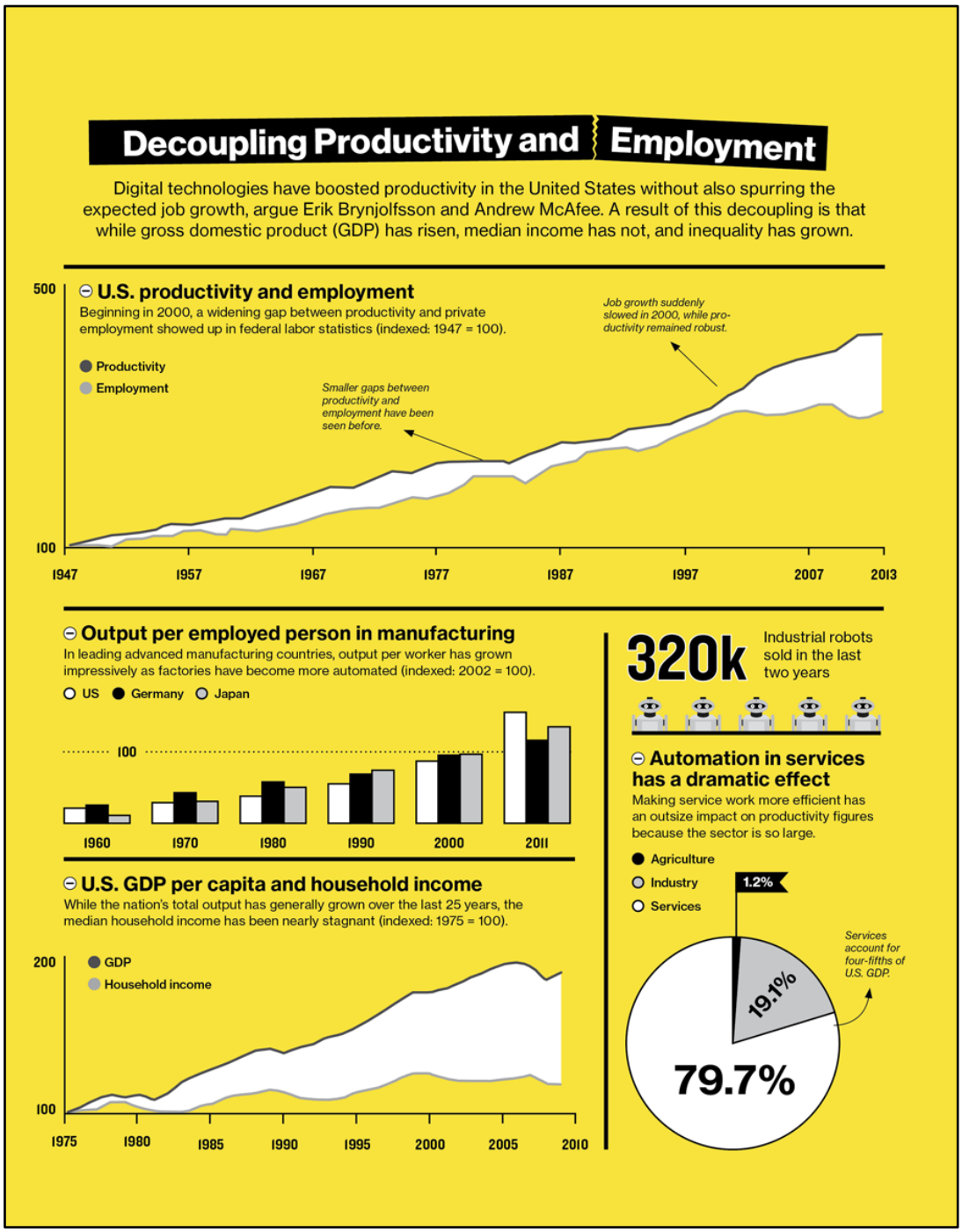


Figure 6:Data on comparison between the rate of change of employment and productivity

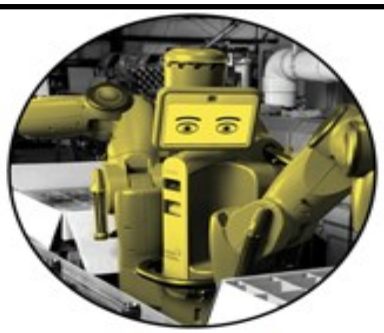
and some workers lost their jobs but high volumes of employment were generated in associated sectors gradually.

The first graph shows two curves- productivity and employment with time.
After the years of World War 2, both productivity and employment kept increasing while maintaining a more or less close gap in between as shown in the graph. Businesses generated more value due to their workers, they benefited and in turn employment increased with the productivity increase.
Roughly around the year 2000, when the internet boom happened, the situation changed. Businesses started requiring more and more highly skilled people to use technological growth to their advantage. Productivity shot up. At the same time, the gap between employment and productivity as shown in the graph widened. People with skills redundant then were the ones unemployed. "It's the great paradox of our era," Brynjolfsson says. "Productivity is at record levels, innovation has never been faster, and yet at the same time, we have a falling median income and we have fewer jobs. People are falling behind because technology is advancing so fast and our skills and organizations aren't keeping up."[13]

Agricultural productivity has increased in the US due to automation. On the other hand, technological growth has caused a 38 per cent decrease in the total population that works in agriculture from 1900 to 2000.

Automation has increased productivity in the manufacturing sector too.
Take the bright-orange Kiva robot, a boon to fledgling e-commerce companies. Created and sold by Kiva Systems, a start-up that was founded in 2002 and bought by Amazon for $775 million in 2012, the robots are designed to scurry across large warehouses, fetching racks of ordered goods and delivering the products to humans who package the orders.
A warehouse equipped with Kiva robots can handle up to four times as many orders as a similar unautomated warehouse, where workers might spend as much as 70 per cent of their time walking about to retrieve goods.
At the same time employment has gone down in major countries like the US.

[13] How Technology Is Destroying Jobs



BAXTER

Rethink Robotics' Baxter is a robot meant to work with people in smaller manufacturing facilities. Its expressive eyes reveal what the robot is "looking" at and let a nearby human know if it's confused.

KIVA

A Kiva Systems robot can scurry about the floor of a large warehouse to find ordered products. It then fetches the correct rack or pallet and brings it to a worker who packages the goods.

WATSON

IBM's Watson, the computer that won at Jeopardy! in 2011, combines artificial intelligence with big data and natural-language processing to advise doctors or callers to customer-support lines.

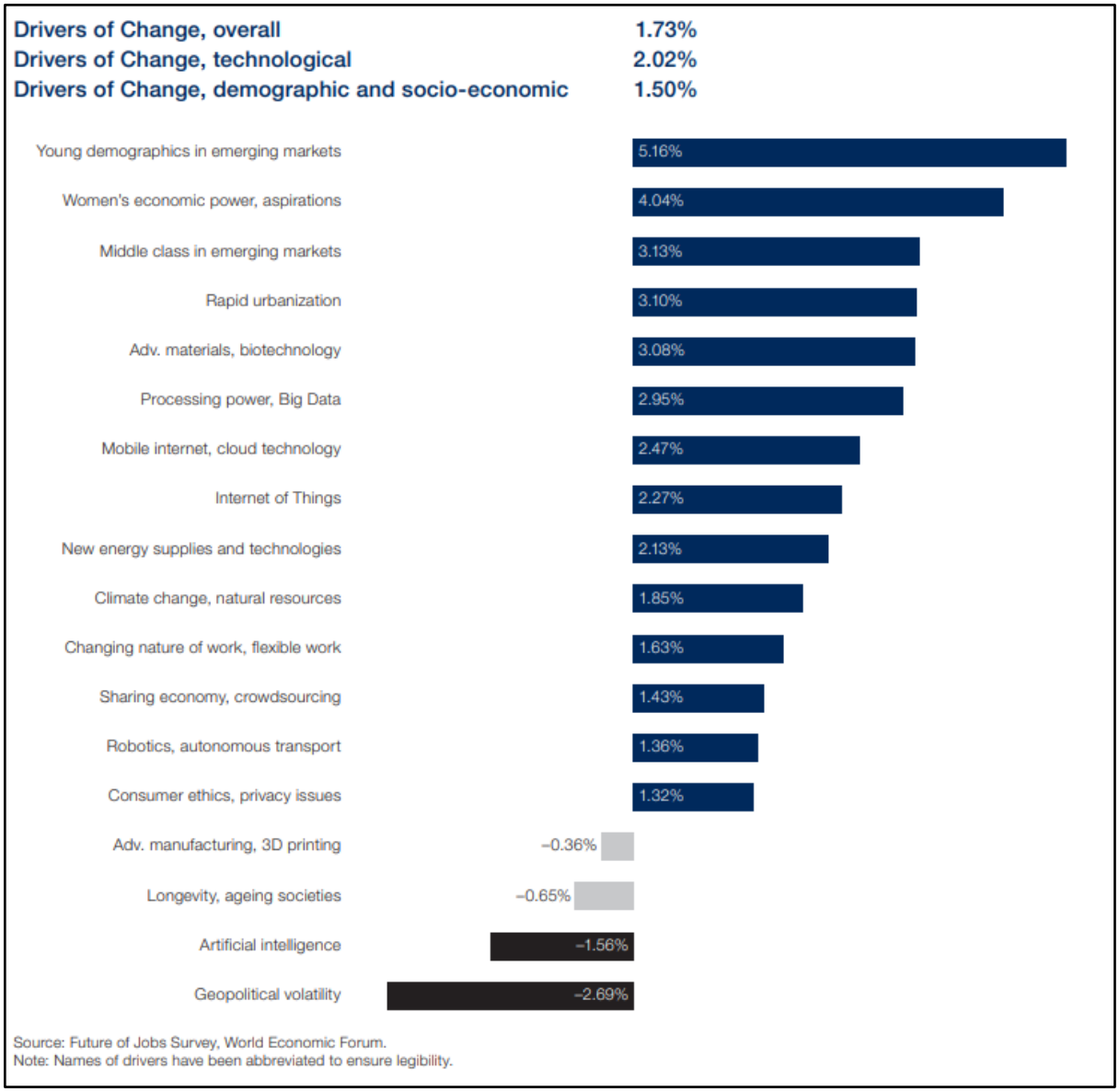


Figure 7Effect of different factors on employment

This figure shows that in the short-term perspective, technologies like AI and Additive Manufacturing have a negative correlation with employment.

Findings

Over the past years, the use of technology by business firms has increased significantly. This has helped in increasing productivity, but at the same time, the rate of employment has declined. The probability of many jobs getting automated has increased and the demand for people who have more in-demand skills has also increased. The effect of technology has negative impacts when accompanied by strict product market regulation and process

innovations. A striking feature of technological progress on employment is that it leads to job polarization. Middle waged jobs (medium level skill requirements) undergo a narrowing due to technological developments while the high and low waged jobs increase.

Objective-2

To determine the demand for various skills and jobs due to technological progress

Introduction

Self-driving cars, X-ray machines, Robot serving machines in hotels are some examples of powerful forms of automation. But it has been found that people with some of the important skills will survive in this machine age. Jobs like bookkeeper, insurance underwriter, credit analyst, telemarketer, etc., which have high potential to be automated are at high risks of getting automated. At the same time, jobs like recreational therapists, dentists, athletic trainers, chemical engineers, etc., have lesser probabilities of getting automated[14].

Hypothesis

Null hypothesis

There will not be any change in demand for skills due to technological advancement.

Alternate hypothesis

The skills demanded will change due to technological growth.

Methodology and Data Sources

Visual models and mathematical models are used to predict the probabilities of an increase in demand for various skills. The data collected by various authors and an article from McKinsey Global Institute is also used to acquire conclusions about the growth and fall of various skills. Data (graphs and figures) have been obtained from the World Economic Forum website from which conclusions have been made to complement the other findings.

Drawing on the methodology used by Bakhshi et al. (2017), a machine learning model built-in TensorFlow is used that correlated a function that maps 120 O*NET variables (skills, knowledge, abilities) to future occupational demand. The function is modelled with the Gaussian Process which prevents overfitting of the model (learning the exact patterns in data

[14] https://www.businessinsider.com

i.e. making the model of prediction incapable) and a heteroskedastic ordinary regression model which varies noise at various points in the feature map.

The O*NET, a survey produced for the US Department of Labour (Occupational Information Network), contains information on more than 1,000 detailed occupations, using a modified form of the (SOC) system. It began in 1998 and is updated on a rolling basis by surveys of each occupation's worker population as well as job analysts' assessments. In its unabridged form, the O*NET-SOC taxonomy includes detailed information on 974 individual occupations in the United States, grouped into approximately 20 broader job families, which are regularly revised and updated for new and emerging occupations to keep up with the changing occupational landscape. Various graphs have been obtained from LinkedIn and Coursera.

i) Job demand probabilities using machine learning

TITLE	EMPLOYMENT	>0.7	>0.5
Preschool, Primary, Secondary and Special Education School Teachers	4,050,880	97.8	100
Animal Care and Service Workers	185,780	93.7	100
Lawyers, Judges and Related Workers	672,580	90.7	98.1
Post-secondary Teachers	1,328,890	83.0	100
Engineers	1,610,470	70.0	100
Personal Appearance Workers	504,640	69.0	100
Social Scientists and Related Workers	239,170	65.6	92
Counselors, Social Workers and Other Community and Social Service Specialists	1,715,190	54.0	100
Librarians, Curators and Archivists	253,800	51.8	62.9
Entertainers and Performers, Sports and Related Workers	483,450	46.4	96.1
Other Management Occupations	2,185,950	42.9	100
Media and Communication Workers	542,570	40.3	89.4
Operations Specialties Managers	1,663,790	29.8	46.5
Religious Workers	68,530	29.6	100
Other Teachers and Instructors	282,640	23.0	100
Other Personal Care and Service Workers	2,619,120	21.9	100
Construction Trades Workers	4,076,790	21.8	64.7
Business Operations Specialists	4,424,800	19.6	77.4
Physical Scientists	266,050	13.8	100
Other Sales And Related Workers	585,030	12.3	14.4
Architects, Surveyors and Cartographers	168,650	11.8	67.3
Other Education, Training, And Library Occupations	1,386,830	10.1	100
Other Healthcare Support Occupations	1,451,710	6.3	51.3
Occupational Therapy And Physical Therapist Assistants And Aides	174,800	4.3	100
Health Diagnosing And Treating Practitioners	4,944,470	4.0	100

Figure 8:Demand for jobs

Education, health, and personal care have high prospects which are in coherence with the growing trends in ageing-related issues, general education of people etc.
Construction traders workers have good prospects too, in coherence with the projected growth due to urbanization and globalization.

TITLE	EMPLOYMENT	<0.3	<0.5
Woodworkers	236,460	100%	100%
Printing Workers	256,040	100%	100%
Metal Workers and Plastic Workers	1,923,050	98.7%	100%
Financial Clerks	3,144,540	97.7%	100%
Other Production Occupations	2,552,400	96.9%	99.4%
Plant and System Operators	311,060	94.1%	100%
Assemblers and Fabricators	1,571,480	92.2%	100%
Communications Equipment Operators	110,250	91.2%	100%
Food Processing Workers	738,030	89.1%	100%
Forest, Conservation and Logging Workers,	42,740	83.9%	100%
Extraction Workers	561,550	81.5%	100%
Financial Specialists	253,530	66.7%	100%
Rail Transportation Workers	2,607,770	66.3%	90.7%
Cooks and Food Preparation Workers	117,460	53.2%	100%
Sales Representatives, Services	3,132,040	49.0%	100%
Retail Sales Workers	8,799,240	44.9%	47.6%
Other Construction and Related Workers	393,710	39.8%	63.2%
Water Transportation Workers	77,270	39.6%	100%
Vehicle and Mobile Equipment Mechanics, Installers and Repairers	1,554,340	38.0%	99.2%
Librarians, Curators and Archivists	253,800	37.1%	37.1%
Material Recording, Scheduling, Dispatching, and Distributing Workers	3,973,730	32.1	97.6%
Other Installation, Maintenance, and Repair Occupations	2,776,890	28.4%	90%
Entertainment Attendants and Related Workers	524,310	25.2%	96.7%
Motor Vehicle Operators	3,797,540	24.3%	100%
Material Moving Workers	4,473,640	20.9%	100%
Other Office and Administrative Support Workers	3,723,230	20.2%	100%
Agricultural Workers	383,890	17.9%	100%
Construction Trades Workers	4,076,790	8.8%	35.3%
Other Healthcare Support Occupations	1,451,710	7.5%	45.7%
Health Technologists and Technicians	2,909,230	6.5%	56.3&
Information and Record Clerks	5,336,050	6.4%	95%
Secretaries and Administrative Assistants	3,680,630	5.5%	100%
Legal Support Workers	344,220	5.1%	100%
Electrical and Electronic Equipment Mechanics, Installers and Repairers	585,280	3.1%	100%
Business Operations Specialists	4,424,800	2.9%	22.6%
Other Protective Service Workers	1,524,350	2.7%	89.8%
Grounds Maintenance Workers	959,960	2.5%	6.7%
Drafters, Engineering Technicians, and Mapping Technicians	680,790	2.2%	74.3%
Life, Physical and Social Science Technicians	359,460	1.8%	82.7%
Other Transportation Workers	305,320	1%	100%

Figure 9:Probabilities of jobs getting automated

Retail sales workers are predicted to have decreasing demands for employment which goes along with the fact that goods and services are being digitized and would no longer require their roles.

Highly automatable roles like clerks, secretaries, drivers are predicted to see a fall in employment rates in harmony with predictions of other sources[15].

Manufacturing sector roles are predicted to see a fall which is accounted for by the ongoing innovations like 3D printing and processes like globalization and urbanisation.

15

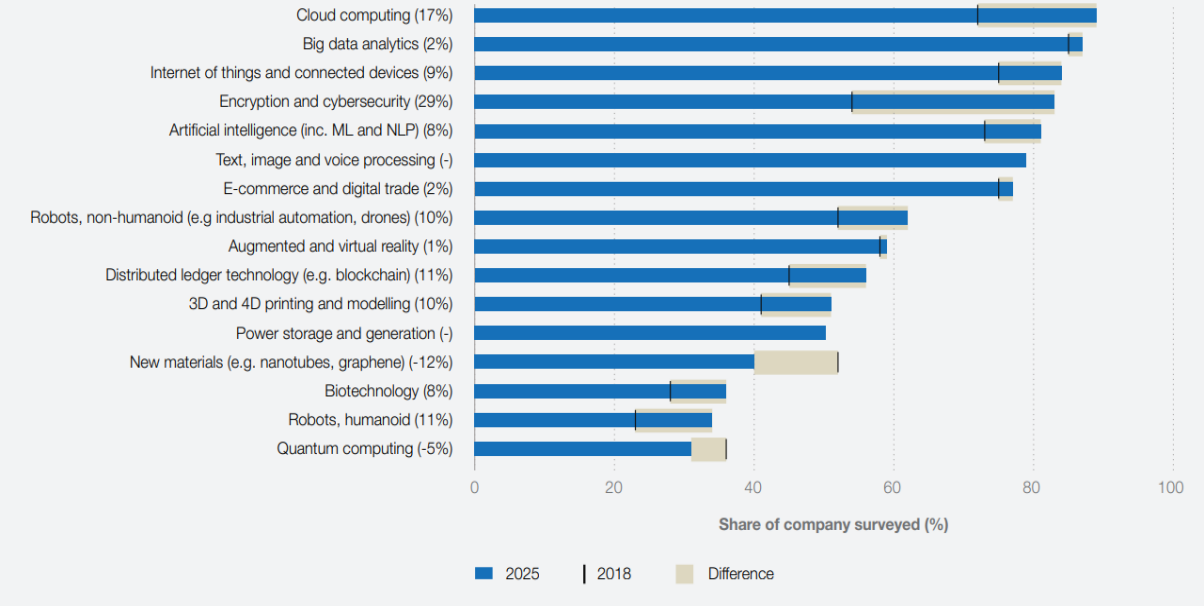


Figure 10:Technologies likely to be adopted by 2025

Industry group	Unstable	Stable
Industries Overall	**35%**	**65%**
Media, Entertainment and Information	27%	73%
Consumer	30%	71%
Healthcare	29%	71%
Energy	30%	70%
Professional Services	33%	67%
Information and Communication Technology	35%	65%
Mobility	39%	61%
Basic and Infrastructure	42%	58%
Financial Services & Investors	43%	57%

Table 1:Skills Stability (2015-2020)

Media, entertainment and information have stability of around 73%. It is human tendency to crave entertainment and knowledge. They are unlikely to be affected by technological progress. Healthcare and biotechnology have also been predicted to have high stability which is in coherence with the previous study.

The world is already moving to conservative and renewable forms of energy. This aligns with the prediction of the high stability of energy-related industries.

As discussed earlier, the results relating to ICT, Infrastructure and financial services are predicted to be stable.

Computers are already running the world, they are expected to undergo further developments in the future. Along with the developments of computers, material science[16] is predicted to progress.

[16] Silicon chips are fundamental to high-speed processors. Solar arrays which help shift to renewables also need the expertise of a material scientist/engineer.

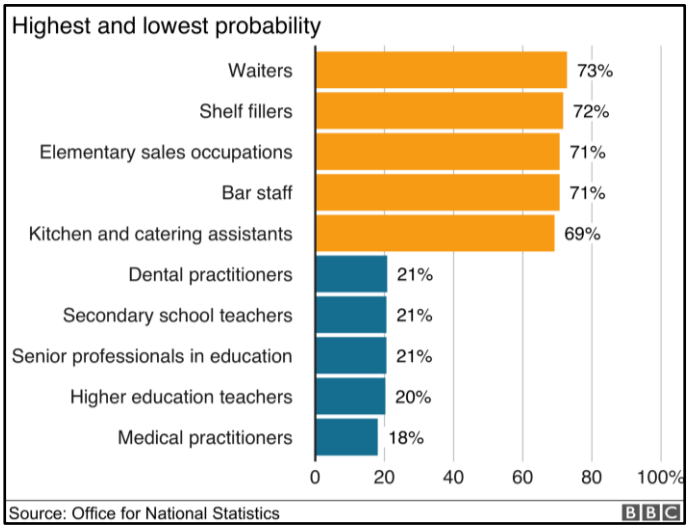


Figure 11:Jobs at risk from automation

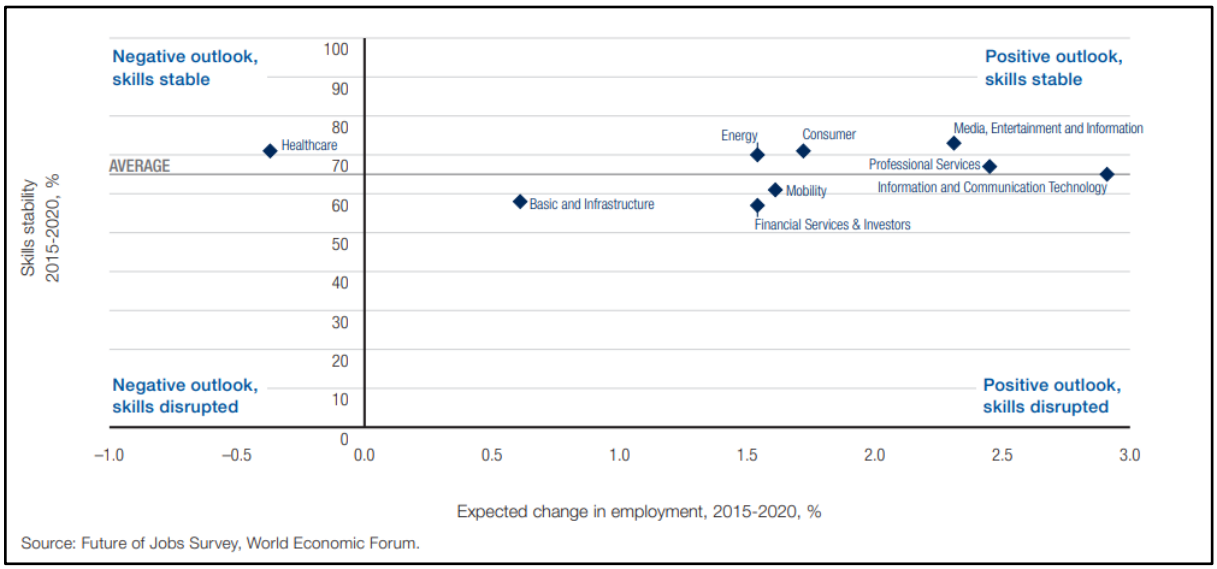


Figure 12:Employment outlook and skills stability, by industry

ii) Importance of Skills

The World Economic Forum has divided the important skills as Business skills, Specialized industry skills, Tech Baseline skills and Tech disruptive skills, along with general and soft skills.

1. **Business skills**: It consists of skills that are required to start or operate a business firm like marketing, management, budgeting and business development.
2. **Specialized Industry skills**: The set of skills that are specific for a particular profession, such as Documentation in Cloud Computing, video and editing in marketing, etc.

3. **General and Soft skills**: They include leadership, communication, negotiation, creativity and problem-solving.
4. **Tech Baseline skills**: They mainly consist of the skills required to work with web design, social media, telecommunications, engineering design software, etc.
5. **Tech Disruptive skills**: The skills that allow the individuals to use and design technologies that can impact business models and the labour market like automation, cybersecurity, robotics, etc.

Also, the World Economic Forum says that soft skills are considered to be the most important foundation to build upon. Some of the important skills that need to be developed are complex problem solving, critical thinking, creativity, people management, coordinating with others, emotional intelligence, judgement and decision making, service orientation, negotiation and cognitive flexibility. They are explained in detail below.

1. **Complex Problem Solving:** The skill to see relationships between industries and craft creative solutions to problems that are yet to appear is a must to keep up with robots and machines.
2. **Critical Thinking:** People who can turn data into insightful interpretations will be sought after due to the complexity and interconnectedness of various fields like computer science, engineering and biology.
3. **Creativity:** The quality of randomness and ability to build something out of ideas.
4. **People Management:** Skills that can be mastered only by human beings like leadership and managerial roles.
5. **Coordinating with others**: Collaborating with people and working together as a team, with effective communication.
6. **Emotional intelligence**: Qualities like empathy and curiosity, required for hiring managers in future.
7. **Judgement and decision making:** The ability to look over various data, analyse and interpret them, along with making important decisions useful for the future.
8. **Service orientation**: People who know the importance of offering value to clients in the form of services and assistance will be in demand as businesses would want to provide solutions to the problems of society.
9. **Negotiation**: The ability to negotiate with businesses and individuals to come up with a win-win situation.

10. **Cognitive Flexibility:** The ability to switch between different personas to accommodate the challenges in society.

Also, the industry sectors which will cherish in future are[17] :

1. Technology and computational thinking
2. Caregiving
3. Social Intelligence
4. Lifelong learning
5. Adaptability and business acumen

The changing nature of activities and capabilities has some important implications in employment. Workers need to be updated and given proper training so that they can learn new skills and continue to work. Also, the growing jobs have higher educational requirements.

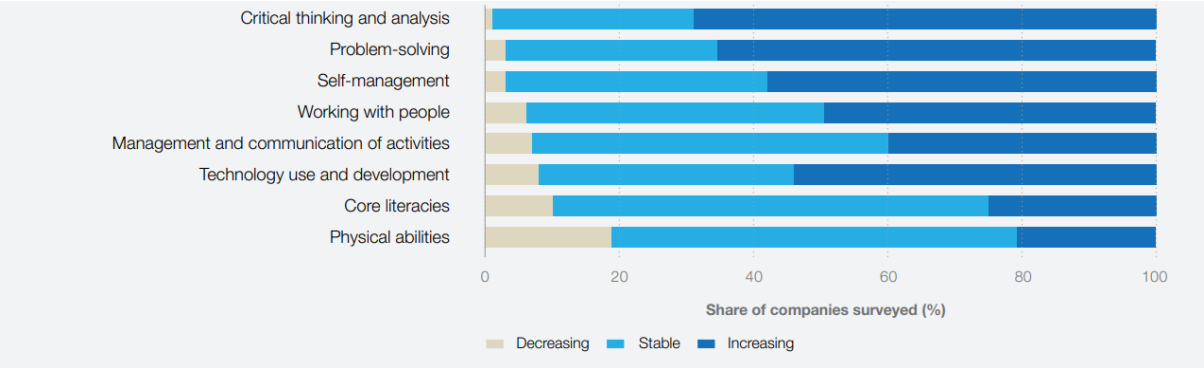


Figure 13:Relative Importance of different skill groups

[17] World Economic Forum, https://www.weforum.org

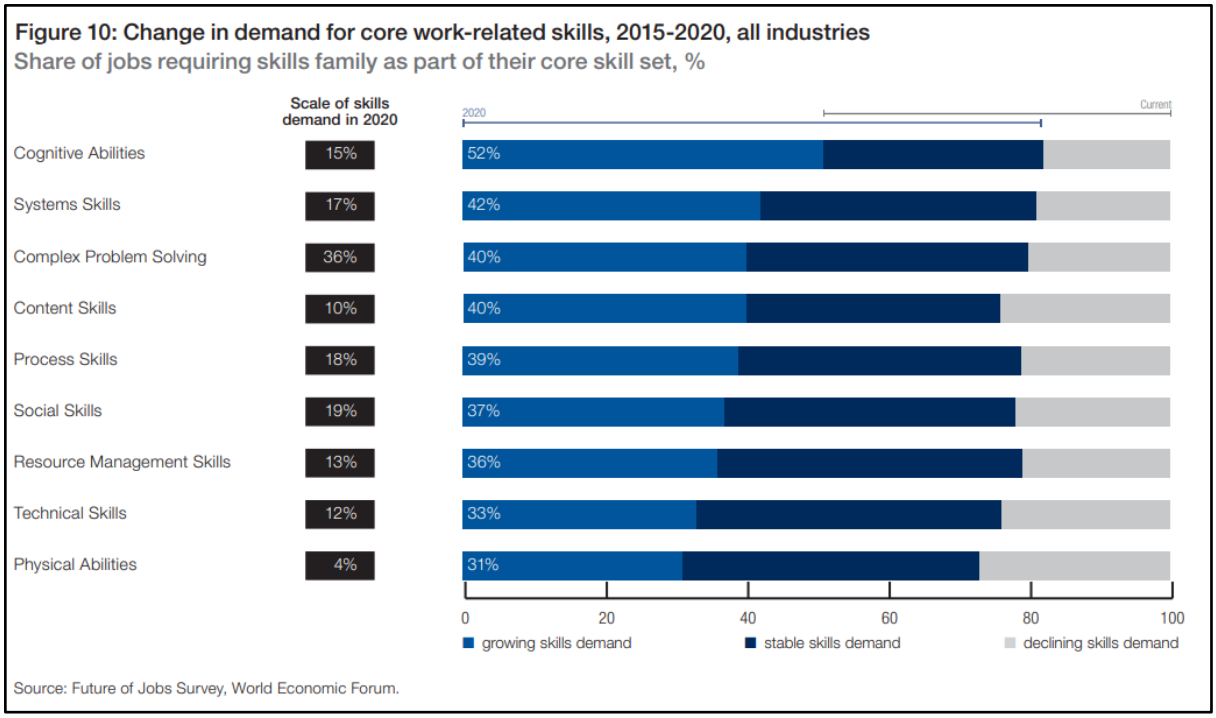


Figure 14:Change in demand for core work-related skills, 2015-2020

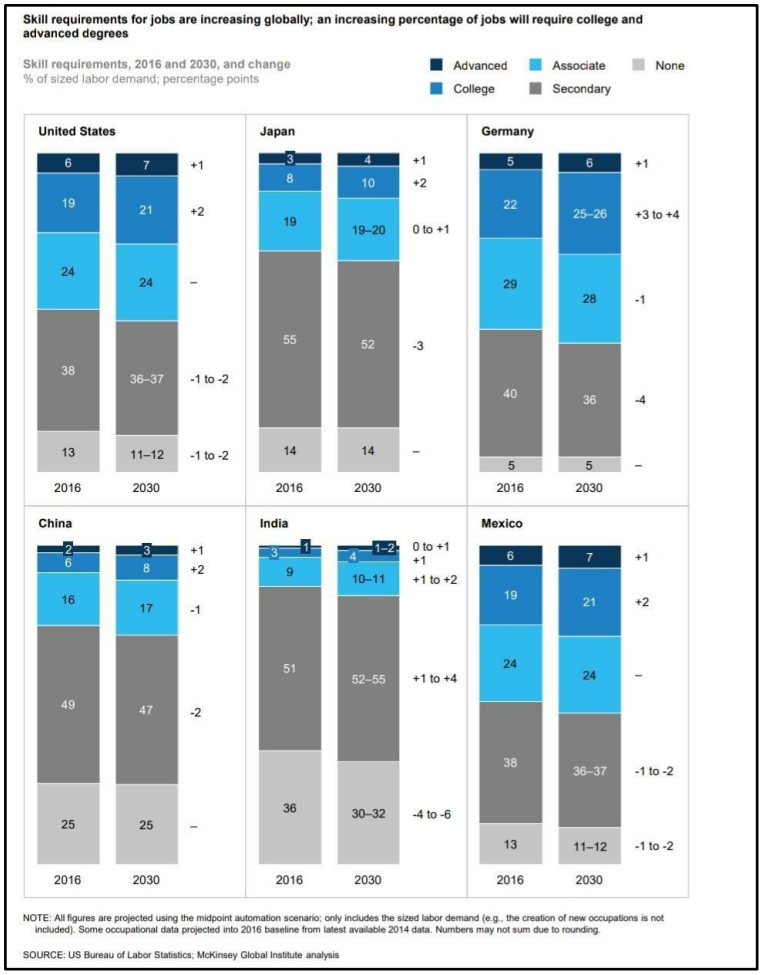


Figure 15:Educational Requirements for jobs in different countries

The above graph[18] shows the skill and educational requirements in six countries with the increase of technological innovations. We can see that in all the six countries, the educational degrees required are more in 2030 than that in 2016. At the same time, the jobs that can recruit those with lower degrees will decrease in future.

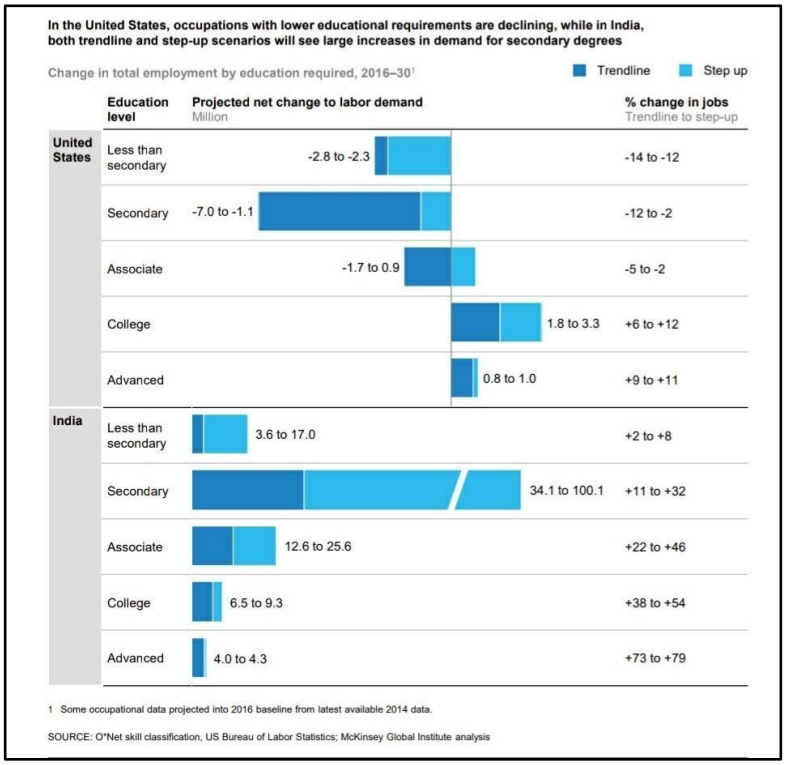


Figure 16:Percentage change in different jobs with

Here[19], we can see that the jobs in the future require people with higher degrees and those with lower educational requirements are declining. But, in India, the jobs that require secondary degrees are increasing because, I think that as our country is at the stage of development, it requires the production of more technological devices and machines, thus ultimately leading to the increasing need for labour.

[18] Jobs lost, jobs gained: Workforce transitions in a time of automation (2017), McKinsey Global Institute.
[19] Jobs lost, jobs gained: Workforce transitions in a time of automation (2017), McKinsey Global Institute.

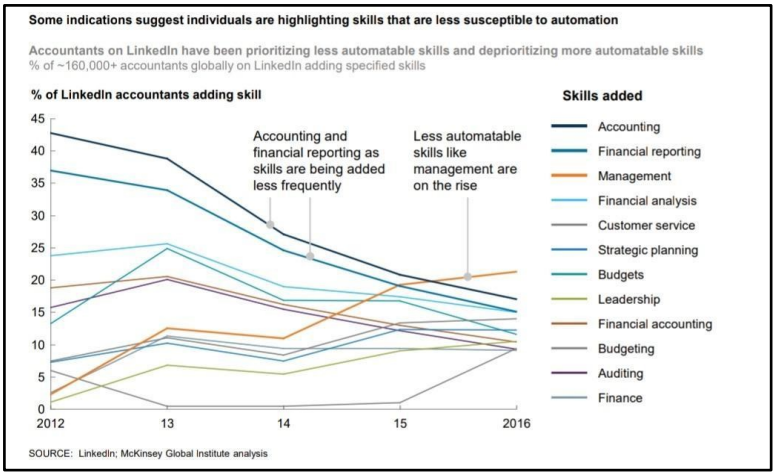


Figure 17:: Employment comparison for different jobs

From the above graph[20], we can see that the employment for jobs like accounting and those which can be automated is declining, while those which cannot be automated tend to increase or remain nearly at the same level.

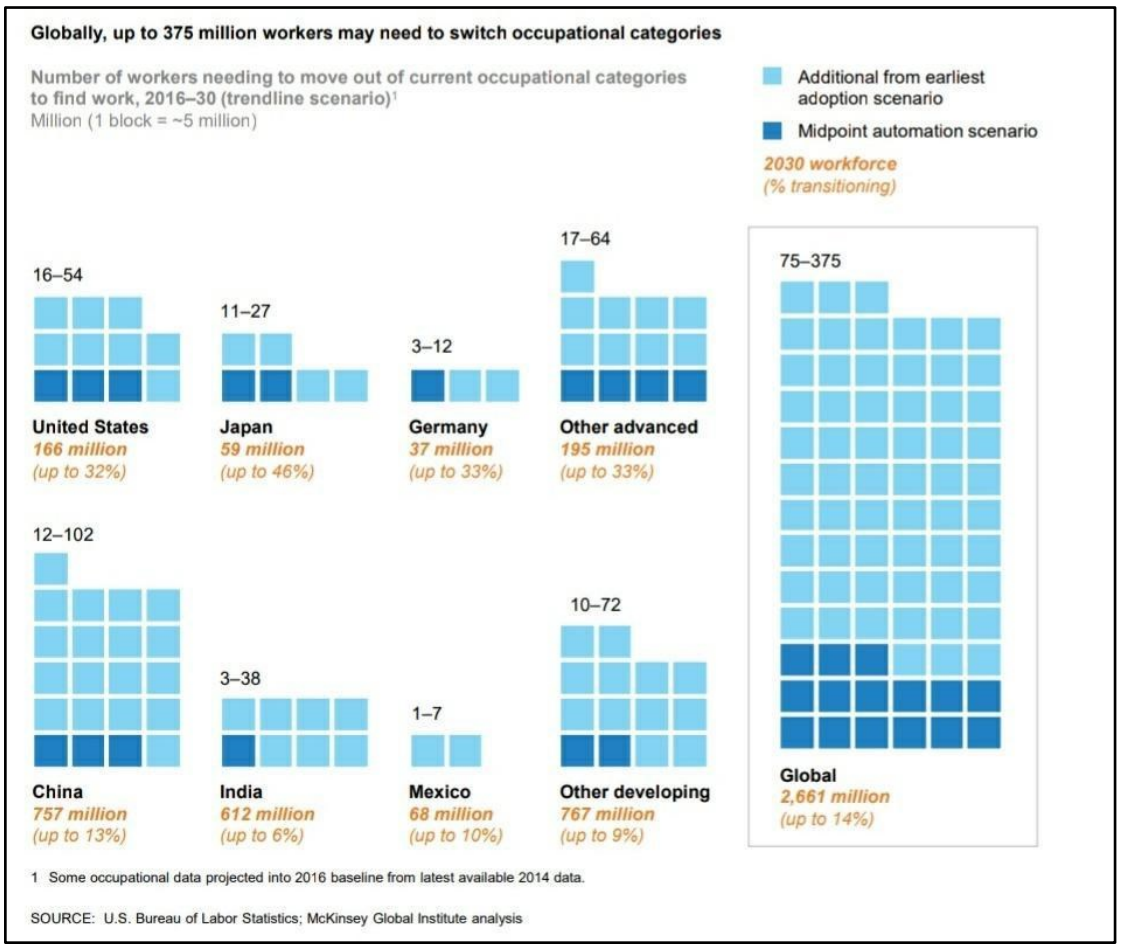


Figure 18:Number of jobs that will be displaced soon

[20]Jobs lost, jobs gained: Workforce transitions in a time of automation (2017), McKinsey Global Institute.

All the above graphs[21] show some important results regarding the skill and educational requirements to survive employment wise in the future.

Findings

The future will be run by machines. COVID-19 has accelerated technological progress more than ever before. Technological developments in the past 18 months have been equivalent to 5 years' worth of technological progress. Coding skills are quintessential for jobs in the coming decade. Energy, education, health, additive manufacturing related jobs have good prospects.

Retail sales related workers, routine automatable jobs are highly likely to be in less demand in the future. Primary high paid roles include data scientist, machine learning and big data analysts. Digital marketing would also be an in-demand role in the future due to reasons like urbanization and globalization.

To survive in this ongoing machine age, skills and educational degrees play an important role. Jobs that require degrees less than secondary are diminishing. Also, jobs like telemarketing will be automated in future. At the same time, jobs like data analysts and customer service representatives will be in high demand in future.

Even today idea generation, complex communication, pattern recognition, and problem-solving are done by humans. These are the weaknesses of computers. Different types of skills would help us in the future and among them, soft skills are considered to be the most important one. People with leadership and management qualities are likely to be recruited more.

[21] Jobs lost, jobs gained,MGI (2017)

Objective-3

Impact of Technology in Women Unemployment

Females account for half of the world population but not half of the world economy. In pre-independence and for even a few decades post-independence the status of women in India in all religions remained in a deprived state. The main reasons are the lack of education and employment opportunities for women. Even in this era of 4G and 5G, we can see much domestic violence towards women in the name of dowry[22]. The status of women was considered subordinate to men in almost every religion. They were not provided with formal education, equal respect given to that of a male child, or property but they were provided with the responsibility to hold the pride of the family in the name of customs. A study shows many women's bank accounts in India are dormant due to the lack of cash flow[23]. Even in the presence of religious fundamentalists the deprived state of women started to vanish mainly due to the employment opportunities due to technological growth. The general perspective on a woman upgraded from a householder who cooks food and takes care of his household to a farmer or a teacher or an IT professional or a doctor or even a statesperson who leads a country/state. Here reasons for the women's deprived state are not being discussed but are the impacts made by technological growth in women unemployment.

Hypothesis

Null hypothesis

There is no difference in the impact made by technological growth between men and women.

Alternate hypothesis

Technological growth helps rural women overcome unemployment problems.

[22] https://www.theleaflet.in/dowry-deaths-in-kerala-indias-most-literate-state/
[23]https://timesofindia.indiatimes.com/india/study-flags-reasons-for-womens-dormant-bank-accounts/articleshow/74483877.cms

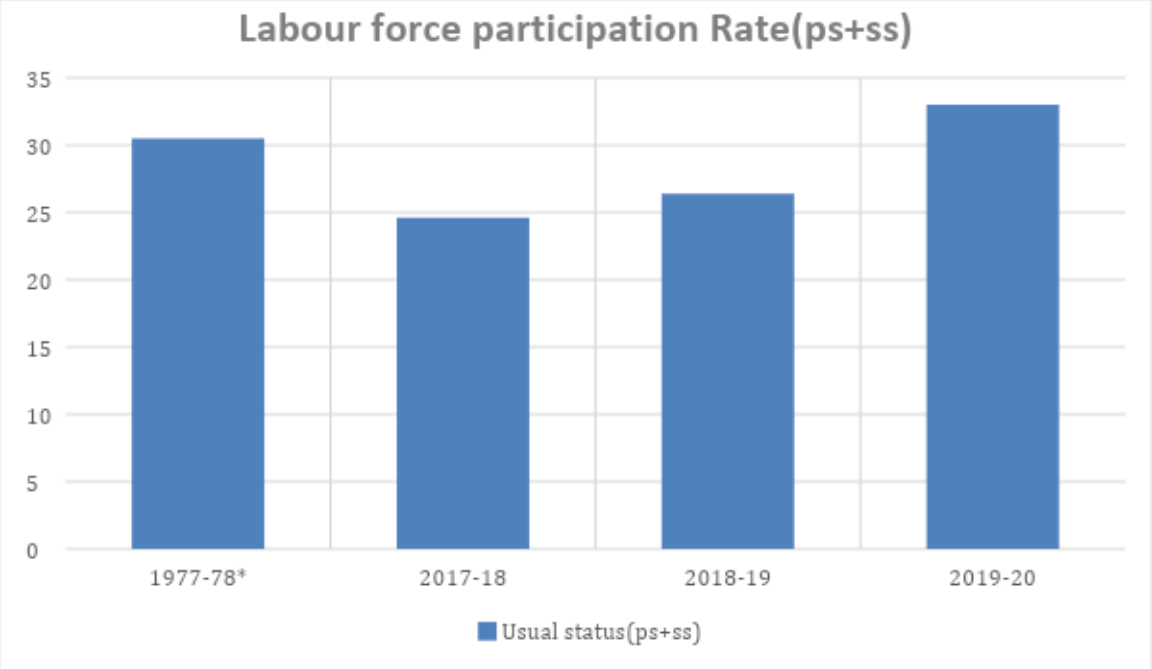
Methodology and Data Sources[24]

Here we use the methodology used by the National Sample Survey Organization (NSSO) to understand the reality of women unemployment in the Indian subcontinent. The terms and codes used in the report refer to the same meaning as that of in NSSO annual report on Periodic Labour Force Survey (PLFS). For the sake of calculating the unemployment rate, we use the usual status.

Bringing women to the Labour-force

Persons who are either 'working' or 'seeking or available for work' constitute the labour force. The participation of women in the labour force is an important indicator of women empowerment. Women getting engaged in employment opportunities is regarded as one of the crucial aspects of their empowerment. Employment opportunities not only enhance the skills and abilities of women, and generate income, but it also brings improvements within their overall quality of life for themselves and of their children, hence that of society. Education plays an important role in bringing women to the labour force. Lured by increasing per capita output (reflected in higher real pay) and released by technology from household drudgery, women have entered the labour force in increasing numbers. The labour participation of rural women has increased from that of the initial years post-independence and that of now. In a survey conducted by NSSO for 2019-20, the female labour participation which is the percentage of females working to total females of age above 15 years was averaged 30% of rural females above 15 years of age are in the labour force.

[24] Refer appendix C



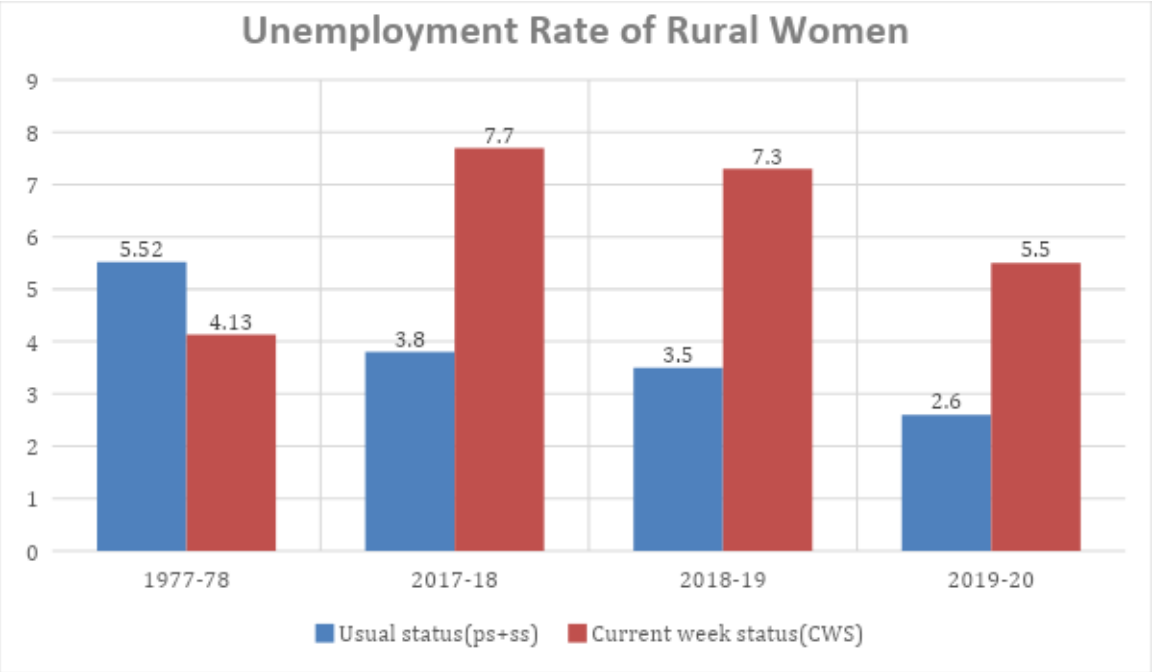
The women in rural areas are hesitant to participate in the labour force due to the burden of working in the workplace after completing household activities. Time taken for household works are reduced by the LPG stoves[25], electric mixer-grinder[26]. This not only reduced the time but also the effort the women have to give to complete the cooking work. The effort and time conserved using this can be usefully utilized in some other works.

Role of Technology in Women Unemployment

Technological growth has provided new opportunities to women. Technological advancements have made the availability of goods and services easier. As discussed above, technological growth not only brings women to the labour force but also decreases the gender gap in the labour force. In urban areas, mostly the women are educated and work in jobs under educational institutions and organizations, whereas, some women establish their businesses, or

[25] https://www.teriin.org/article/women-ujjwala
[26] https://doi.org/10.1080/19439342.2017.1343368

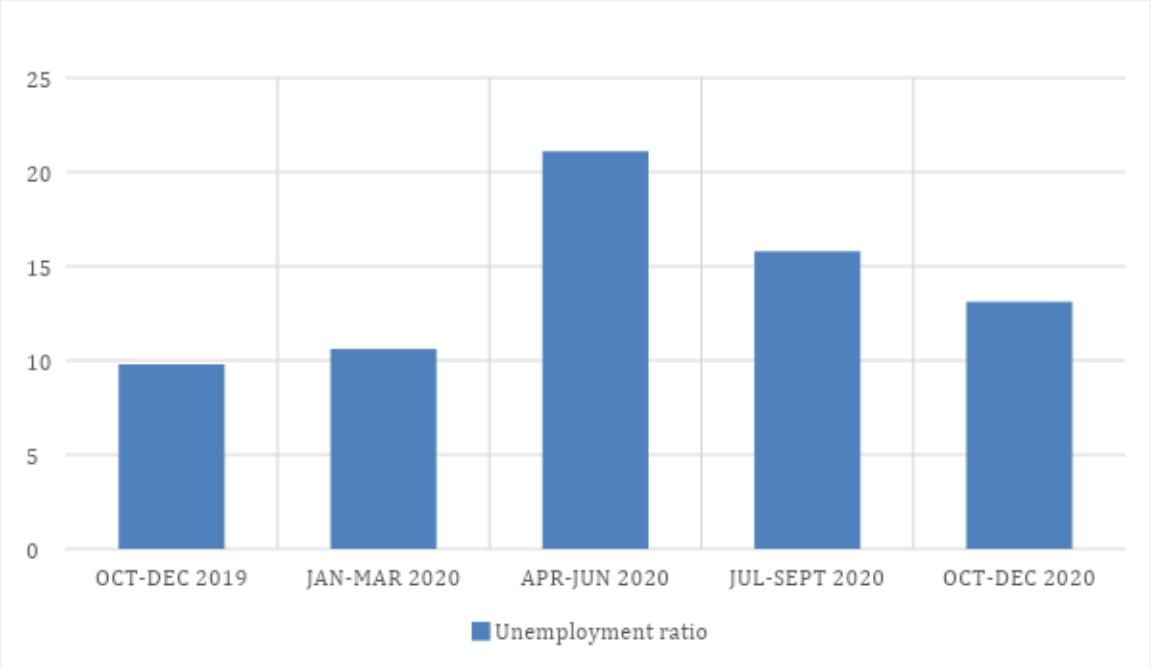
set up nursery schools or training centres. But this is not the case with rural women.



Rural women mostly work either directly or indirectly in agriculture-based jobs. In the earlier times, agricultural jobs were meant only for men and the women's part in agriculture is de-weeding and regularly irrigating the field. But as a result of social reforms, the women started to enter the labour force of agriculture but their physique made not every woman do every job conveniently. And then when automation came into existence almost every job can be done by every person regardless of their physique. For example, before the tractor came into agriculture the only way to plough the field is by cattle which is usually not done by women and when the tractor came the women were able to plough the field[27]. Also, almost every technological growth helps women to leap employment. This has also been reflected in the unemployment rates. A survey conducted by NSSO in the year 1977-78 says that the unemployment rate of rural females i.e., the percentage of rural females in the labour force based on usual status considering principal and subsidiary statuses together is 5.52% whereas that in 2019-20 is 2.6%.

The higher values of current week unemployment in recent years can be a result of jobs which don't give work every month in a year. The female unemployment rate in the current week status from October month of 2019 to December of 2020 is as follows.

[27] https://www.rural21.com/fileadmin/downloads/2020/en-01/rural2020_01-S41-43.pdf



This chart shows the fact that the jobs in the rural areas are not uniform over the year and also some persons have work in some months and others have work in some other months.

Discussion

Inferring to the data of rural women from the PLFS we can find a fact that the condition of women in work was somehow better in 1977-78 and worse in the years 2017-18 and 2018-19. The reason for this cannot be found using just this data. But it somehow improved in 2019-20. Considering the complete lockdown situation and a deprived economic condition of the country in the year 2019-20 the data seems not to reflect the condition in the annual report which makes us doubt the procedure of survey in that year[28] but the quarterly reports show the increased unemployment rate in April – June of 2020.

Despite the unemployment of rural women decreasing in usual status the current week status unemployment rate has grown tremendously. Maybe MGNREGA and other temporary employment schemes are the reason for this. Even though these schemes don't employ every month the main goal of the scheme "providing a minimal job opportunity" have been achieved. The role of technology in rural women unemployment can be found in the increasing labour force participation and also in reducing the unemployment rate.

[28] Refer Appendix C

Findings

We conclude that the growing technology boosts women empowerment by bringing women into the labour force participation. The automation and fewer physical requirements are found to increase the participation of women and it also increases a healthy skill-oriented competition. Also, the policies of the government to provide a minimum employment opportunity seems to have worked. To decrease different unemployment rates in different months the minimum working days under the schemes can be increased or the days can be well distributed over the year.

Suggested policies to tackle the ill-effects of technological progress on employment

The most important policy that we would suggest is the upskilling of the workforce. From the research, it is visible that skills mismatch is the main cause of technological unemployment. Degrees should not be made mandatory for jobs. Instead, the necessary skills should be made a key factor. In this way, people need not spend 4-5 years in college for education, if they could learn the same skills within a year or two. Online courses (a boon of technological development) can be provided by the government free of cost for the upskilling of its people.

The idea of learning for life must be imparted. Out of 1 billion people in India, very few have that mindset to keep learning. Like most habits that are imparted, this one too can be taught to children in schools. Rather than rote learning subjects of no interest, students must be given opportunities to find their passion and explore it even more. Once this mindset is set people can achieve whatever they want when matched with the right time and people. This is the primary reason why many educational/information start-ups are so successful in the world. Government should provide its people with regular workshops for upskilling/information exchange to feed the people's minds.

Since technological growth is accelerating (COVID has accelerated it even further), the government should incentivize tech start-ups and companies.

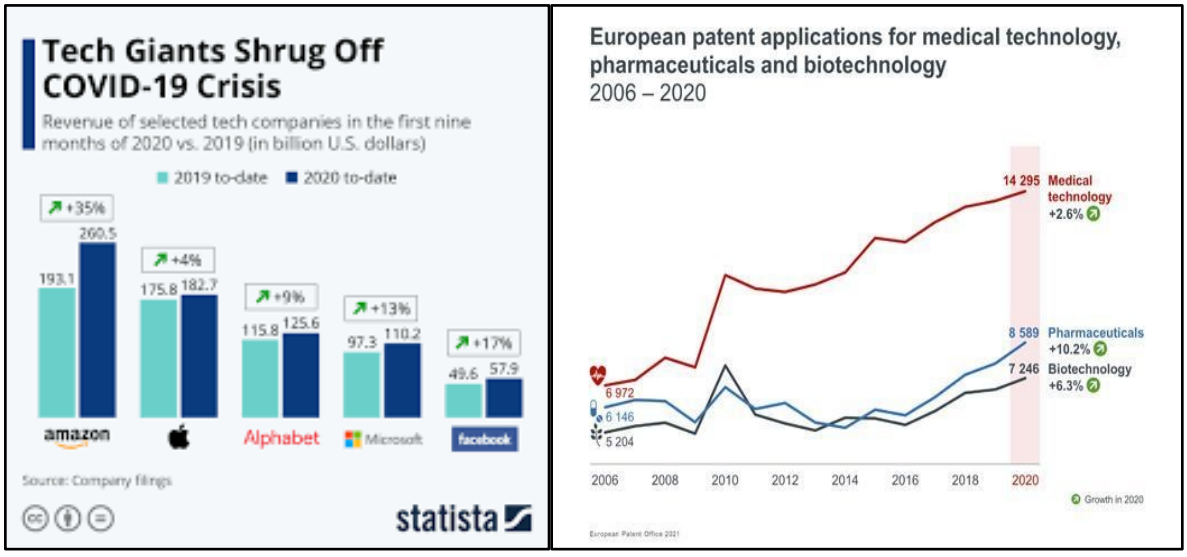


Figure 19:Trends of technological growth during COVID-19

One of the main problems of India is its brain drain. Every year hundreds of students from top institutes move out of the country or work for foreign companies. The youth should remain the centre of focus. Initiatives like Start-up India must be made more efficient and effective. The fact that a successful start-up employs hundreds of people in addition to having an end goal is what makes start-ups so capable.

To provide time for upskilling the people to cope-up with technological growth, the government can make provisions for temporary jobs. These could be in sectors like health, technology, education etc. In addition, knowledge about the various job-relevant skills must be spread through mass media so that people can spend time improving those skills.

Conclusion

Technological developments are predicted to have a positive impact on employment.
Due to technological changes, the future requires workers to have different skills. Soft skills have always been important skills and they have been predicted to be even more important in the future due to digitalization. Digital marketing and artificial intelligence-related sectors have good prospects. Powerful suggestions for coping up with the 4th Industrial revolution have been given. The probability of many jobs getting affected by automation has increased.
The paper has made many conclusions from visual models. Mathematical modelling is required for further confirmation of the results. Time frames of studies are different for different objectives which may cause discrepancies in the results produced.

References

Acharya, N. G. (2021). *Dowry deaths in Kerala, India's Most Literate State*. https://www.theleaflet.in/dowry-deaths-in-kerala-indias-most-literate-state/

Agbozo, E., Masih, A., & Turygina, V. (2016). *THE EFFECTS OF TECHNOLOGY ON EMPLOYMENT (WHAT THE FUTURE HOLDS)*.

Bajaj, K. (2018, August 03). *The women of Ujjwala*. The Energy and Resources Institute. https://www.teriin.org/article/women-ujjwala

Bakhshi, H., Downing, J., Osborne, M., & Schneider, P. (2017). *THE FUTURE OF SKILLS EMPLOYMENT IN 2030*. Schneider.

Dash, D. K. (2020, March 5). Study flags reasons for women's dormant bank accounts. *The Time of India*. https://timesofindia.indiatimes.com/india/study-flags-reasons-for-womens-dormant-bank-accounts/articleshow/74483877.cms

David, J., & Wessel, D. (1998). *Prosperity: The Coming Twenty-Year Boom and What It Means to You*. Times Books.

IBM. (2019). *MIT-IBM Watson AI Lab Releases Groundbreaking Research on AI and the Future of Work*. IBM. https://newsroom.ibm.com/2019-10-30-MIT-IBM-Watson-AI-Lab-Releases-Groundbreaking-Research-on-AI-and-the-Future-of-Work

International Labour Organisation. (2018). *The impact of technology on the quality and quantity of jobs*.

J, R. (1995). *The End of Work - The Decline of the Global Labor Force and the Dawn of the Post-Market Era*.

Lima, Y., Barbosa, C., & de Souza, J. (2021). Understanding Technological Unemployment: A Review of Causes, Consequences, and Solutions. *Societies*, *11*(2), 50. https://www.mdpi.com/2075-4698/11/2/50#cite

Marchant, G. E., Stevens, Y. A., & Hennessy, J. M. (2014, February). Journal of Evolution and Technology. *Technology, Unemployment & Policy Options: Navigating the Transition to a Better World*, *24*(1), 26-44.

Mello, A. (2020, July 23). *COVID-19 has sped up digital transformation by 5.3 years, says the study*. IoTNOW. https://www.iot-now.com/2020/07/23/104031-covid-19-has-sped-up-digital-transformation-by-5-3-years-says-study/

National Academy of Engineering & Chamot, D. (1983). *The Long-Term Impact of Technology on Employment and Unemployment*. The National Academies Press. 10.17226/19470

Otekhile, C.-A., & Zeleny, M. (2016). *Self Service Technologies: A Cause of Unemployment*, *4*(1), 2016.

Periodic Labour Force Survey (PLFS) Annual Report 2017-18. (2019). Ministry of Statistics and Programme Implementation.

Periodic Labour Force Survey (PLFS) Annual Report 2018-19. (2020). Ministry of Statistics and Programme Implementation.

Periodic Labour Force Survey (PLFS) Annual Report 2019-20. (2021). Ministry of Statistics and Programme Implementation.

Rotman, D. (2013). *How Technology Is Destroying Jobs*. MIT technology review. https://www.technologyreview.com/2013/06/12/178008/how-technology-is-destroying-jobs/amp/

Shahkooh, K. A., Azadnia, M., & Shahkooh, S. (2008). *An Investigation into the Effect of Information Technology on the Rate of Unemployment*. IEEE. DOI 10.1109/ICCIT.2008.259

Tanja Winther, Margaret N. Matinga, Kirsten Ulsrud & Karina Standal (2017) *Women's empowerment through electricity access: scoping study and proposal for a framework of analysis,* Journal of Development Effectiveness, 9:3, 389-417, DOI: 10.1080/19439342.2017.1343368

Tewari, J.N. (1981). Women's activity in Rural India. *National sample survey organization*, *IV Nos 3&4*(Department of statistics), 20-45. N.A

Ugur, M., Churchill, S., & Solomon, E. (2018, February). Technological innovation and employment in derived labour demand models: A hierarchical meta-regression analysis. *Journal of Economic Surveys*, *32*(1), 50-82. 10.1111/joes.12187

Vashisht, P. (2017). *Destruction or Polarization: Estimating the Impact of Technology on Jobs in Indian Manufacturing*, (334).

World Economic Forum. (2016, January). *The Future of Jobs Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution*.

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

Appendix A

E-Readiness Score

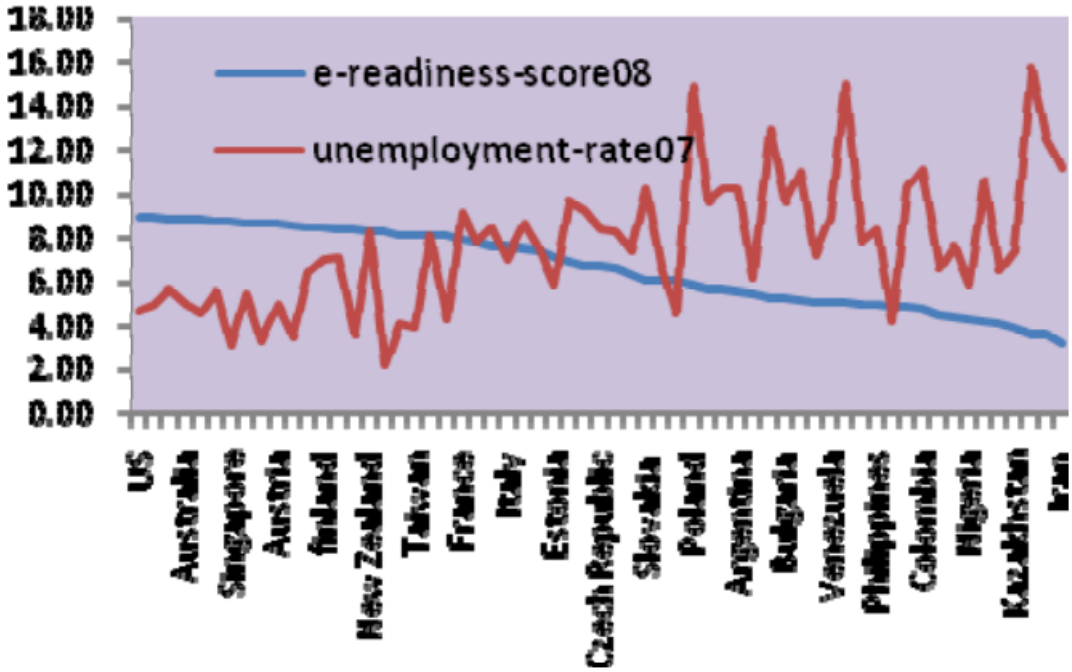


Figure 20: Relation between e-readiness and unemployment rate

Cluster	Countries	Cluster centre
1	US, Hong Kong, Sweden, Australia, Denmark, Netherland, Singapore, UK, Switzerland, Austria, Norway, Canada, Finland, Germany, South Korea, Bermuda, Japan, Taiwan, Ireland, Estonia, Lithuania, China	E-readiness score = 8.20 Unemployment rate = 4.69

2	New Zealand, Belgium, France, Malta, Israel, Italy, Spain, Portugal, Slovenia, Greece, Czech Republic, Chile, Hungary, Slovakia, Latvia, Brazil, Turkey, Argentina, Romania, Bulgaria, Peru, Venezuela, India, Philippines, Egypt, Russia, Sri Lank, Nigeria, Pakistan, Kazakhstan.	E-readiness score = 6.02 Unemployment rate = 8.23
3	Poland, Saudi Arabia, Jamaica, Jordan, Colombia, Ecuador, Algeria, Indonesia, Iran	E-readiness score 4.50 Unemployment rate = 12.78

As e-readiness score and unemployment rate have an inverse relation, 61 countries are classified into 3 clusters using SPSS software. K-means clustering in SPSS is used to find the number of clusters and categorization of countries into adequate clusters (according to e-readiness score and unemployment rate). The results of the analysis are presented in table 1. In the first cluster, there are countries with high e-readiness and low unemployment. The second and third clusters are countries with more unemployment and less e-readiness.

Appendix B

Causes of technological unemployment

1. Skills mismatch - unemployment is caused when the skills of workers don't match the requirements of the job. Automation is a big issue for unskilled workers because of its inherent purpose of reducing and making work more efficient (than that done by humans). The growth in technology forces people to learn more skills at a faster rate. So, if technological growth happens at a huge rate, many will be unemployed.
2. International tax systems - They are not equipped to handle the changes caused by technological growth. This goes against the principle of equality for developing countries as they would be texted the same as developed countries, thus causing unemployment.
3. Oligopoly in technology - A few tech giants like Google, Amazon and countries like the USA and China that are technologically advanced make investments in technology (like AI) that cause unemployment in developing countries. They are not affected much because their population is mostly high-skilled and employed.
4. It becomes increasingly difficult as the population of a country increases to allocate resources and manage employment.
5. Government efficiency - legal complexities and low infrastructure decrease chances of employment.
6. Less financial and market support to small scale industries.

Appendix C

PLFS fieldwork during COVID-19 pandemic

The fieldwork of PLFS was suspended from 18.03.2020 due to the COVID-19 pandemic. The fieldwork of the pending FSUs for January - March 2020 and the fieldwork of FSUs allotted for canvassing during April – June 2020 was resumed on 1st June 2020. Although schedules were canvassed later, the information was asked concerning the actual reference period which would have been adopted if there were no pandemics. Thus, there was no break in the flow of information collected for any quarter except that informants were approached at a later date due to the unavoidable situation. On resumption of fieldwork in June 2020, the field officials were advised that the canvassing of revisit schedules was to be undertaken telephonically, as per actual reference periods of samples, in the original paper revisit schedules. The telephonic mode was adopted for revisit Schedules to minimise the physical interaction with informants to contain the spread of the COVID virus and to cope up with pandemic related restrictions

Geographical coverage:

The survey covered the whole of the Indian Union except the villages in Andaman and Nicobar Islands which remained extremely difficult to access throughout the year.

Sample Design of PLFS

A rotational panel sampling design has been used in urban areas. In this rotational panel scheme, each selected household in urban areas is visited four times – at the beginning with the first visit schedule and thrice periodically later with revisit schedule. In the urban area, samples for a panel within each stratum were drawn in the form of two independent sub-samples. There was no revisit in the rural samples. For rural areas, samples for a stratum/sub-stratum were drawn randomly in the form of two independent sub-samples. For rural areas, in each quarter of the survey period, 25% FSUs of annual allocation was covered.

A stratified multi-stage design was adopted for PLFS. The first stage units (FSU) were the Urban Frame Survey (UFS) blocks in urban areas and the 2011 Population Census villages (Panchayat wards for Kerala) in rural areas. The ultimate stage units (USU) were households. In the case of large FSUs one intermediate stage unit, called hamlet group/sub-block, was formed.

In urban areas, strata were formed within each NSS region on the basis of size class of towns as per Population Census 2011. The rural areas, each NSS region constituted a rural stratum. In case of rural sectors of Nagaland, a special stratum was formed within the State

consisting of all the villages which were difficult to access. In urban areas there was no sub-stratification. In rural areas, 'r/8' sub-strata were formed in each rural stratum, if 'r' was the annual sample size allocated for a rural stratum. The villages within a stratum as per frame were first arranged in ascending order of population. Then sub- strata 1 to 'r/8' were demarcated in such a way that each sub-stratum comprised a group of villages of the arranged frame and had more or less equal population.

At all-India level a total of 12,800 FSUs (7,024 villages and 5,776 UFS blocks) were allotted for survey annually. State/UT level samples were allocated between two sectors in proportion to population as per Census 2011 with double weightage to urban sector in general. Within each sector of a State/UT, the respective sample size was allocated to the different strata (in the case of urban areas) and strata/ sub-strata (in the case of rural areas) in proportion to the population as per Census 2011. Urban allocations at stratum level were adjusted to multiples of 8 with a minimum sample size of 8 (for 4 panels, each of size multiple of 2). Rural allocation for each stratum was also multiple of 8 with minimum sample size of 8 (for 4 quarters, each of size 2).

Urban FSUs were selected by probability proportional to size with replacement (PPSWR) scheme, size being the number of households in the UFS block. Samples for a panel within each stratum were drawn in the form of two independent sub-samples. To implement the rotational scheme, 4 groups of sample FSUs of equal size (each multiple of size 2, half for each of sub-sample 1 and sub-sample 2) were drawn randomly. In the rural areas, samples for a stratum/sub-stratum were drawn randomly in the form of two independent sub-samples with probability proportional to size with replacement (PPSWR) scheme, size being the population of the village and equal number of samples were allocated among the four quarters. All households listed in a village/UFS block where no hamlet- group/sub-block formation was done, or the households listed in the two selected hamlet- groups/sub-blocks of the village/UFS block where hamlet-group/sub-block formation was done, constituted the sampling frame of households. All the households listed in the selected village/ hamlet-groups were stratified into three second stage strata (SSS) and all the households listed in the selected UFS block /sub-blocks were stratified into four second stage strata (SSS). A total of 8 households were selected from each sample village/block for canvassing the detailed schedule. The sample households from each of the second stage strata were selected by SRSWOR.

The domains of rural and urban sector in the survey are co-terminus with the criterion adopted in census. The urban frame used in the survey was the latest updated UFS that took into account the newly declared towns after the last census 2011. Accordingly, the rural sector is the one that is not urban.

Activity status:

It is the activity situation in which a person was found during a specified reference period with regard to the person's participation in economic and non-economic activities. According to this, a person could be in one or a combination of the following three broad activity statuses during the reference period:

i. working or being engaged in economic activity (work),

ii. being not engaged in economic activity (work) but either making tangible efforts to seek 'work' or being available for 'work' if 'work' is available and

iii. being not engaged in any economic activity (work) and also not available for 'work'.

Usual activity status(ps+ss):

The usual activity status relates to the activity status of a person during the reference period of 365 days preceding the date of survey. The activity status on which a person spent relatively long time (major time criterion) during the 365 days preceding the date of survey was considered the usual principal activity status of the person. To decide the usual principal activity of a person, he/ she was first categorised as belonging to the labour force or not, during the reference period on the basis of major time criterion. Persons, thus adjudged as not belonging to the labour force were assigned the broad activity status 'neither working nor available for work'. For the persons belonging to the labour force, the broad activity status of either 'working' or ‘not working but seeking and/ or available for work’ was then ascertained again on the basis of the relatively long time spent in the labour force during the 365 days preceding the date of survey. Within the broad activity status so determined, the detailed activity status category of a person pursuing more than one such activity was determined again on the basis of the ‘relatively long time spent’ criterion

Current weekly activity status (CWS):

The current weekly activity status of a person is the activity status obtained for a person during a reference period of 7 days preceding the date of survey. It is decided on the basis of a certain priority cum major time criterion. According to the priority criterion, the status of 'working' gets priority over the status of 'not working but seeking or available for work', which in turn gets priority over the status of 'neither working nor available for work'. A person is considered working (or employed)) if he/ she worked for at least one hour on at least one day during the 7 days preceding the date of survey or if he/she had work for at least 1 hour on at least one day during the 7 days preceding the date of the survey but did not do the work. A person is considered 'seeking or available for work (or unemployed)' if during the reference week no economic activity was pursued by the person but he/ she made efforts to get work or had been available for work for at least one hour on any day during the reference week. A person who had neither worked nor was available for work any time during the reference week, is considered to be engaged in non-economic activities (or not in the labour force). Having decided the broad current weekly activity status of a person on the basis of 'priority' criterion, the detailed current weekly activity status is again decided on the basis of 'major time' criterion if a person was pursuing multiple economic activities.

Labour Force Participation Rates (LFPR):

LFPR is defined as the percentage of persons in the labour force in the population.

$$\frac{no.\ of\ employed\ persons + no.of\ unemployed\ persons}{total\ population} * 100$$

TABLE 10 : PERCENTAGE OF RURAL FEMALES IN THE LABOUR FORCE AND NOT IN THE LABOUR FORCE TO POPULATION OF AGE 5 YEARS AND ABOVE ACCORDING TO USUAL STATUS, CURRENT WEEKLY STATUS AND CURRENT DAY STATUS BY SEX FOR ALL-INDIA AND STATES

all-India/state/ union territory	usual status		current weekly status		current day status	
	LF	NLF	LF	NLF	LF	NLF
(1)	(2)	(3)	(4)	(5)	(6)	(7)
All-India	30·51	69·49	28·06	71·94	24·84	75·16
Andhra Pradesh	47·90	52·10	42·63	57·37	39·65	60·36
Assam	7·97	92·03	7·82	92·18	6·77	93·23
Bihar	19·93	80·07	17·09	82·91	15·76	84·24
Gujarat	33·97	66·03	34·46	65·54	27·73	72·27
Haryana	16·06	83·94	18·61	81·39	13·18	86·82
Himachal Pradesh	52·22	47·78	45·51	54·49	36·66	63·34
Jammu & Kashmir	14·47	85·53	16·70	83·30	12·65	87·35
Karnataka	39·22	60·78	35·50	64·50	31·67	68·33
Kerala	29·74	70·26	27·65	72·35	22·71	77·29
Madhya Pradesh	43·70	56·30	37·31	62·69	33·95	66·05
Maharashtra	47·90	52·10	43·58	56·42	39·72	60·28
Manipur	34.06	65.94	31·54	68·46	27·39	72·61
Meghalaya	62·83	37·17	60·00	40·00	51·92	48·08
Orissa	27·05	72·95	21·20	78·80	18·95	81·05
Punjab	11·77	88·23	20·34	79·66	13·91	86·09
Rajasthan	39·47	60·53	41·36	58·64	36·64	63·36
Tamil Nadu	42·09	57·91	40·35	59·65	36·09	63·91
Tripura	38·29	61·71	33·60	66·40	30·44	69·56
Uttar Pradesh	19·39	80·61	18·33	81·67	15·95	84·05
West Bengal	14·33	85·67	10·95	89·05	9·89	90·11
Arunachal Pradesh	63·93	36·07	59·67	40·33	55·29	44·71
Delhi	9·69	90·31	9·20	90·80	6·82	93·18
Goa, Daman and Diu	42·60	57·40	37·13	62·87	33·58	66·42
Pondicherry	27·10	72·90	22·21	77·79	17·73	82·27

LF—In labour force.
NLF—Not in labour force.

Figure 21:Labour participation of rural females (1977-78)

Statement 7: Labour force participation rates (in per cent) in usual status (ps+ss) in PLFS (2017-18), PLFS (2018-19) and PLFS (2019-20) for persons of 15-29 years, 15 years & above and all persons

all-India

age group	rural			urban			rural+urban		
	male	female	person	male	female	person	male	female	person
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
PLFS (2019-20)									
15-29 years	60.8	20.7	41.3	58.3	20.3	40.0	60.0	20.6	40.9
15 years and above	77.9	33.0	55.5	74.6	23.3	49.3	76.8	30.0	53.5
all ages	56.3	24.7	40.8	57.8	18.5	38.6	56.8	22.8	40.1
PLFS (2018-19)									
15-29 years	58.8	15.8	37.8	58.6	17.1	38.7	58.8	16.2	38.1
15 years and above	76.4	26.4	51.5	73.7	20.4	47.5	75.5	24.5	50.2
all ages	55.1	19.7	37.7	56.7	16.1	36.9	55.6	18.6	37.5
PLFS (2017-18)									
15-29 years	58.9	15.9	38.1	58.5	17.5	38.5	58.8	16.4	38.2
15 years and above	76.4	24.6	50.7	74.5	20.4	47.6	75.8	23.3	49.8
all ages	54.9	18.2	37.0	57.0	15.9	36.8	55.5	17.5	36.9

Figure 22:Labour force participation rate from LPFS report 2019-20

Unemployment Rate (UR):

UR is defined as the percentage of persons unemployed among the persons in the labour force

$$\frac{no.of\ unemployed\ persons}{no.\ of\ employed\ persons + no.of\ unemployed\ persons} * 100$$

TABLE 22 : INCIDENCE OF UNEMPLOYMENT OF RURAL FEMALES ACCORDING TO USUAL STATUS, CURRENT WEEKLY STATUS AND CURRENT DAY STATUS FOR ALL-INDIA AND STATES

all-India/state/union territory	usual status	current weekly status	current day status
(1)	(2)	(3)	(4)
All-India	5·52	4·13	9·18
Andhra Pradesh	5·22	8·26	14·33
Assam	5·83	1·13	1·35
Bihar	3·98	4·37	9·23
Gujarat	1·74	1·70	5·61
Haryana	20·79	1·46	3·17
Himachal Pradesh	0·61	0·04	0·18
Jammu & Kashmir	5·78	1·60	2·25
Karnataka	4·13	4·68	11·54
Kerala	29·18	12·84	27·41
Madhya Pradesh	0·75	1·83	3·39
Maharashtra	1·89	4·06	9·31
Manipur	0·56	0·16	0·18
Meghalaya	0·15	—	0·05
Orissa	4·43	5·57	9·67
Punjab	14·30	1·01	2·11
Rajasthan	2·89	1·39	1·96
Tamil Nadu	6·27	5·27	17·11
Tripura	4·11	1·56	3·64
Uttar Pradesh	3·20	1·24	2·98
West Bengal	23·86	3·69	9·91
Arunachal Pradesh	0·07	—	0·25
Delhi	4·63	20·00	26·80
Goa, Daman and Diu	5·19	11·48	14·97
Pondicherry	32·34	7·24	23·77

Figure 23:1977-78 Rural female Unemployment rate (usual status ps+ss)

Statement 24: Unemployment rates (in percent) according to usual status (ps+ss) and current weekly status (CWS) during PLFS (2017 – 2018), PLFS (2018-19) and PLFS (2019-20)

all-India

status	PLFS (2019-20)			PLFS (2018-19)			PLFS (2017-18)		
	male	female	person	male	female	person	male	female	person
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
				rural					
usual status (ps+ss)	4.5 (2.5)	2.6 (0.6)	4.0 (1.6)	5.6 (3.1)	3.5 (0.7)	5.0 (1.9)	5.8 (3.2)	3.8 (0.7)	5.3 (2.0)
CWS	8.7 (4.8)	5.5 (1.2)	7.9 (3.0)	8.7 (4.8)	7.3 (1.2)	8.4 (3.0)	8.8 (4.8)	7.7 (1.2)	8.5 (3.1)
				urban					
usual status (ps+ss)	6.4 (3.7)	8.9 (1.6)	7.0 (2.7)	7.1 (4.0)	9.9 (1.6)	7.7 (2.8)	7.1 (4.0)	10.8 (1.7)	7.8 (2.9)
CWS	10.6 (6.0)	12.4 (2.2)	11.0 (4.1)	8.9 (5.0)	12.1 (1.9)	9.5 (3.5)	8.8 (5.0)	12.8 (2.0)	9.6 (3.5)
				rural+urban					
usual status (ps+ss)	5.1 (2.9)	4.2 (0.9)	4.8 (1.9)	6.0 (3.4)	5.2 (1.0)	5.8 (2.2)	6.2 (3.4)	5.7 (1.0)	6.1 (2.2)
CWS	9.3 (5.2)	7.3 (1.5)	8.8 (3.4)	8.8 (4.8)	8.7 (1.4)	8.8 (3.2)	8.8 (4.8)	9.1 (1.4)	8.9 (3.2)

Figures in parenthesis give the proportion of unemployed (PU) person in the population in per cent

Figure 24Three years' Unemployment ratio

Unemployment Rate (UR) (in per cent) according to usual status (ps+ss)
The year 2018-19

State/UT	rural			urban			rural + urban		
	male	female	person	male	female	person	male	female	person
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Andhra Pradesh	4.9	3.9	4.5	6.2	10.2	7.3	5.3	5.3	5.3
Arunachal Pradesh	6.1	12.7	7.3	7.4	29.0	11.1	6.3	15.3	7.9
Assam	6.2	6.8	6.3	9.9	15.5	10.7	6.5	7.8	6.7
Bihar	10.6	1.7	10.2	10.4	12.3	10.5	10.6	3.3	10.2
Chhattisgarh	2.6	0.7	1.8	4.6	7.8	5.5	3.0	1.6	2.4
Delhi	0.6	0.0	0.5	10.9	9.9	10.8	10.6	9.6	10.4
Goa	2.4	19.7	8.0	6.9	14.4	9.1	5.3	16.4	8.7
Gujarat	3.8	1.8	3.3	3.4	2.5	3.2	3.6	2.0	3.3
Haryana	10.0	6.7	9.5	8.6	8.9	8.7	9.6	7.6	9.2
Himachal Pradesh	5.3	4.3	4.8	6.5	14.9	8.8	5.4	4.8	5.2
Jammu & Kashmir	2.9	6.0	3.9	5.6	27.2	10.1	3.5	8.8	5.1
Jharkhand	5.8	0.6	4.5	8.7	8.4	8.7	6.4	1.6	5.3
Karnataka	3.2	1.4	2.7	5.0	6.1	5.2	3.9	2.8	3.6
Kerala	4.7	15.6	8.4	5.2	18.8	9.7	5.0	17.1	9.0
Madhya Pradesh	3.0	0.7	2.4	7.7	6.2	7.4	4.2	1.6	3.5
Maharashtra	4.6	3.3	4.2	5.2	10.6	6.4	4.9	5.5	5.0
Manipur	7.7	15.6	9.8	9.8	7.7	9.2	8.3	13.1	9.6
Meghalaya	1.9	2.1	2.0	4.6	13.3	7.5	2.3	3.3	2.7
Mizoram	4.2	8.1	5.2	7.4	12.7	9.1	5.6	10.4	7.0
Nagaland	14.4	21.4	16.2	15.4	42.9	21.1	14.7	26.2	17.5
Odisha	6.6	4.2	6.1	10.1	21.9	12.7	7.2	6.6	7.0
Punjab	7.6	8.3	7.7	6.1	11.3	7.0	7.0	9.4	7.4
Rajasthan	5.9	2.1	4.6	8.5	14.2	9.5	6.6	3.7	5.7
Sikkim	3.0	1.8	2.5	3.9	7.5	4.9	3.2	2.8	3.1
Tamil Nādu	7.0	5.5	6.4	6.0	8.4	6.7	6.6	6.5	6.6
Telangana	8.2	4.7	6.8	9.0	17.7	11.2	8.6	8.1	8.4
Tripura	5.5	28.3	9.3	8.7	30.1	13.5	6.1	28.7	10.1
Uttarakhand	5.3	13.3	7.2	10.2	30.0	13.4	6.7	16.8	8.9
Uttar Pradesh	4.8	1.8	4.3	11.2	6.1	10.6	6.3	2.5	5.7
West Bengal	4.0	1.4	3.5	5.3	3.7	4.9	4.4	2.3	3.9
Andaman & N. Island	6.7	34.2	14.6	3.5	38.2	12.0	5.3	35.7	13.5
Chandigarh	0.0	9.1	1.6	7.7	9.7	8.2	7.3	9.7	7.9
Dadra & Nagar Haveli	1.8	0.0	1.1	1.3	5.4	1.8	1.5	1.3	1.5
Daman & Diu	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lakshadweep	39.2	45.6	40.0	21.8	48.7	28.6	26.9	48.3	31.6
Puducherry	12.5	10.0	11.6	6.3	5.2	6.0	8.7	7.6	8.3
All India	**5.6**	**3.5**	**5.0**	**7.1**	**9.9**	**7.7**	**6.0**	**5.2**	**5.8**

Table 2:2018-19 unemployment rates

Table 3:2019-20 Rural female Unemployment rate (usual status ps+ss)

Table (18): Unemployment Rate (UR) (in per cent) according to usual status (ps+ss) for each State/UT

age group: all ages(0+)

State/UT	rural			urban			rural + urban		
	male	female	person	male	female	person	male	female	person
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Andhra Pradesh	4.4	3.0	3.9	6.3	7.8	6.7	5.0	4.1	4.7
Arunachal Pradesh	5.4	9.2	6.3	8.4	11.4	9.0	5.9	9.5	6.7
Assam	6.8	12.9	7.8	6.3	18.3	8.7	6.7	13.7	7.9
Bihar	5.4	0.5	4.8	8.1	12.4	8.6	5.7	1.7	5.3
Chhattisgarh	3.2	1.1	2.3	8.6	9.4	8.8	4.1	1.9	3.3
Delhi	2.5	0.0	2.0	8.7	10.2	8.9	8.5	9.8	8.7
Goa	5.7	12.5	7.6	7.1	11.6	8.4	6.6	11.9	8.1
Gujarat	2.0	0.1	1.4	2.9	3.4	3.0	2.4	1.1	2.0
Haryana	6.8	4.9	6.5	6.0	8.4	6.5	6.5	6.5	6.5
Himachal Pradesh	4.4	2.3	3.4	4.1	9.7	5.9	4.4	2.8	3.7
Jharkhand	4.5	0.4	3.0	9.6	9.5	9.6	5.6	1.3	4.2
Karnataka	3.0	2.2	2.7	3.9	15.4	6.8	3.4	6.2	4.2
Kerala	7.3	13.8	9.7	7.5	16.7	10.4	7.4	15.1	10.0
Madhya Pradesh	2.3	0.5	1.7	7.4	5.5	7.0	3.7	1.4	3.0
Maharashtra	3.2	1.1	2.5	4.0	5.6	4.4	3.5	2.4	3.2
Manipur	8.4	12.3	9.5	11.0	8.8	10.2	9.1	11.1	9.7
Meghalaya	1.0	1.4	1.1	7.5	18.3	10.9	2.1	3.6	2.7
Mizoram	4.8	2.8	4.2	7.1	8.8	7.7	5.8	5.6	5.7
Nagaland	25.2	26.9	25.8	23.4	30.9	25.7	24.8	27.8	25.8
Odisha	7.3	3.6	6.1	7.6	8.0	7.7	7.3	4.1	6.3
Punjab	7.4	6.4	7.2	6.6	11.6	7.7	7.1	8.2	7.4
Rajasthan	4.1	1.8	3.2	9.4	7.4	9.0	5.5	2.5	4.5
Sikkim	2.5	1.4	2.0	2.8	3.0	2.9	2.5	1.7	2.2
Tamil Nadu	6.0	3.4	5.0	5.3	6.9	5.8	5.7	4.7	5.3
Telangana	6.3	3.7	5.2	9.7	12.0	10.3	7.7	5.8	7.0
Tripura	3.0	2.5	2.8	4.7	4.2	4.6	3.3	2.8	3.2
Uttarakhand	7.8	3.9	6.5	7.6	15.5	9.1	7.8	5.6	7.1
Uttar Pradesh	3.8	1.1	3.2	8.5	10.2	8.8	4.9	2.7	4.5
West Bengal	4.8	2.8	4.4	5.3	4.9	5.2	5.0	3.6	4.6
Andaman & N. Island	6.3	26.5	12.7	6.3	28.6	12.4	6.3	27.3	12.6
Chandigarh	3.1	36.5	9.9	6.1	6.0	6.1	6.0	7.6	6.3
Dadra & Nagar Haveli	1.7	0.0	1.0	5.7	0.3	5.0	4.1	0.1	3.0
Daman & Diu	4.3	0.0	3.2	2.6	3.4	2.8	2.9	2.7	2.9
Jammu & Kashmir	3.5	8.4	5.2	7.2	29.9	13.2	4.3	11.6	6.7
Ladakh	0.0	0.0	0.0	1.5	0.0	1.0	0.2	0.0	0.1
Lakshadweep	0.7	36.7	10.7	13.9	17.0	14.7	10.6	22.2	13.7
Puducherry	6.8	9.2	7.6	6.2	11.0	7.6	6.4	10.3	7.6
all India	**4.5**	**2.6**	**4.0**	**6.4**	**8.9**	**7.0**	**5.1**	**4.2**	**4.8**