The Future of Work in India

Adapting to the Fourth Industrial Revolution

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Executive Summary

Since 1991, India has undergone a series of economic reforms that have accelerated its integration into the global economy. Reduced trade barriers, removal of barriers to foreign investment, and simplified regulations helped bring India into an age of rapid, service sector-led growth. However, the gains from this breakout have not reached every Indian. Inequality continues to widen, as a freer market has exacerbated existing class divisions in income, wealth, and access to skills and capital.

These social challenges have been the hallmarks of India's transition into the digital economy, in which ICTs have enabled commerce and opportunity to pour in from around the globe at the cost of opportunity and social mobility for India's most excluded citizens. Inequality and social prejudices prevent these groups from gaining the literacies and technical competencies necessary to participate in the formal sector of this new economy. For more than 80 percent of workers without access to formal employment, a shadowy and unproductive informal sector remains as the only source of income, testifying to a much higher rate of unmeasured unemployment among those seeking to profit to the fullest from their abilities in a way that headline statistics do not show.

As India has continued its transition into the digital economy, a new technological revolution is starting which, in the long term, will revolutionize the future of work and the nature of the economy. In the modern digital economy, machines are capable of automating simple and predictable tasks, but humans fill in to bring the nuance, complexity and creativity our technology cannot yet provide. Yet new advances in computing power, the growing ubiquity of internet-connected devices, and algorithms which mimic the cognitive processes of human thought are building a world in which complex and unpredictable processes can be automated through the sheer weight of predictive data. In the process, work tasks currently seen as reserved for humans can increasingly be ceded to machines, threatening to upend paradigms of employment in place throughout human history.

India would appear vulnerable to these tectonic changes, as a large share of its economy is already vulnerable to automation through technologies already widely available. However, in the next few decades, India is unlikely to experience significant job loss from automation. Labor costs are low enough that implementing the expensive infrastructure and systems required to facilitate automation does not make economic sense, especially in the informal sector where the vast majority of individuals work. These technologies may, however, eliminate jobs that have served as traditional ladders for social mobility in a time of inequality. They will also elevate the digital platform economy into a position of dominance, requiring labor reforms to address the unforeseen challenges that result.

Moving forward, India should develop a framework for formal protections in the emerging digital gig economy, which straddles the formal and informal sectors. Education initiatives promoting reskilling and upskilling should be expanded, as lifelong learning becomes more and more important for adapting to changing realities in the labor market. Finally, the government should consider policies to redistribute gains from technology and incentivize advances in the fields that reflect India's development priorities.

Historical Context

Economic Crisis and Reform

In the year 1991, India found itself teetering on the brink of a catastrophic economic crisis. For decades, the national economic development plan had placed its emphasis on industrialization through import substitution and the promotion of cottage industries. In addition to these protectionist measures, cumbersome business regulations pushed by a bloated public sector undermined the growth of entrepreneurship and private enterprise, and unwieldly five-year plans blunted the state's ability to respond nimbly to changing global circumstances. While growth was not high, India had successfully insulated itself from the international currents that could potentially derail the postcolonial nation's dreams of wealth, development, and equality. Or so the government thought.

The sum effect of these measures was to make India far less globally competitive than its South and East Asian neighbors in a newfound era of globalization. With the fall of the Berlin Wall and the end of the Cold War came a concurrent erasure of the barriers that had become entrenched around two competing global ecosystems. Alongside this sea change in the international political and economic landscape came a wave of disruption, as the parameters that had defined global trade for over forty years shifted beneath the world's feet. In the case of India, which had embraced an economic model that had hollowed out the ability of its industries to compete on the world stage, these changes threatened drastic consequences. Paradoxically, the policies underlying India's import substitution industrialization strategy instead caused imports to soar by undercutting domestic competitiveness. The Gulf War exacerbated the emerging balance of payments problem that resulted as foreign oil became more expensive and exports dried up. By mid-1991, the government was having difficulty paying its foreign debts, the currency was in freefall, and foreign exchange reserves had nearly vanished. At one point, the Reserve Bank of India pledged 47 tons of gold to the Bank of England to secure an emergency loan from the IMF, only to have the van carrying the gold break down on its way to the airport.[1] Truly, the economic situation seemed to have hit rock bottom.

Help came in the shape of a raft of reforms introduced by Prime Minister Narasimha Rao in collaboration with Finance Minister Manmohan Singh, a future Prime Minister himself. The reforms kicked off with a formal 20% devaluation of the currency, which, while drawing domestic ire for apparently caving into foreign demands, patched India's balance of payments issues long enough to address broader structural issues. Gradually, the measures which had brought an unstable macroeconomic regime to the point of collapse were dismantled. Tariffs and duties were lowered, state monopolies were dissolved, barriers to foreign investment were lowered, and the vast and confusing system of permits, licenses, regulations and red tape surrounding private enterprise collectively known as the License Raj was taken apart.

With these far-reaching reforms came a new era of rapid growth for India and a simultaneous change in international perceptions about the country's economic dynamism.

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[1] https://economictimes.indiatimes.com/news/economy/finance/when-47-tonnes-of-gold-was-in-the-middle-of-road/articleshow/59447917.cms

Whereas India's prior stagnation had previously and lazily been attributed to amorphous cultural aspects, India was instead on the way to proving itself as a rapidly growing, rising economic power, a critical cog in the machinery of an emerging global economy and an indispensable engine of growth. From a mere 1.06% in 1991, GDP growth skyrocketed to an average annual rate of 7%. Growth has not dropped below 4% at any point since reforms were initiated, and reached a high of 10.3% in 2010. India has continued to liberalize over these intervening decades, albeit in fits and starts, and according to former RBI Governor Raghuram Rajan, additional structural reforms could firmly place India on a 10% annual growth trajectory.[2]

The principal driver of this growth has been the breakout of the service sector. As global businesses operated in an era of globalization made possible not just by tectonic changes in international politics, but also the introduction of revolutionary new Information and Communications Technologies (ICTs), India revealed itself as one of the world's most competitive providers of global business services. Initially, India's comparative advantage in providing these services was due to its use of English as an official language and its low labor costs; liberalization merely allowed foreign companies which had once been blocked from operating in India to take advantage of these existing conditions. The first participants in the Indian IT revolution were largely only given responsibility for back office work, to be completed while main offices in the West were closed for business. Since then, major industrial clusters have emerged around these IT hubs, and academic specialization in the STEM fields providing graduates with quality work opportunities has skyrocketed.[3] These developments have broadened the labor force's involvement in the global economy while deepening it by propelling Indian workers up the value chain to take responsibility for more lucrative, higher skilled tasks.

India has charted a largely unprecedented course as a developing country by largely bypassing the manufacturing stage of export-oriented industrialization in favor of services-led growth. Over the past decade, the services sector has been responsible for 63% of India's economic growth.[4] Today, the service sector isn't just the largest contributor to the Indian economy and the employer of 28% of the Indian workforce.[5] It is also the fastest growing services sector in the world. One of the main drivers for this has been explosive growth in outsourcing and IT-enabled services, with India now hosting 55% of the 190 billion USD global services sourcing industry.[6] With 75% of global digital talent, increasing levels of education specifically in IT fields have also made Indian work in the field more innovative and competitive, pushing numerous international IT firms to build innovation centers in India to take advantage of this new fountain of human capital. IT can be expected to continue leading growth in the service sector, and by extension in the Indian economy, with expected 7-9% annual growth rates through the near future.[7]

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[2] https://www.cnbc.com/2018/03/19/indias-economy-needs-to-grow-10-percent-former-imf-chief-economist.html
[3] https://academiccommons.columbia.edu/doi/10.7916/D8H1319M
[4] https://www.ilo.org/wcmsp5/groups/public/---asia/---ro-bangkok/---sro-new_delhi/documents/publication/wcms_631296.pdf
[5] [6] https://www.ciiblog.in/indian-services-sector-multi-trillion-dollar-opportunity-for-global-symbiotic-growth/
[6] https://www.ibef.org/industry/information-technology-india.aspx
[7] https://economictimes.indiatimes.com/tech/ites/indian-software-services-sector-to-grow-7-9-in-fy19-nasscom/articleshow/62995685.cms

The Third Industrial Revolution

In retrospect, the sweeping changes that India experienced in the wake of its economic liberalization were a harbinger of the country's entry into and participation in the Third Industrial Revolution. While the Industrial Revolution conventionally refers to the emergence of new manufacturing techniques in the early 19ᵗʰ century, it should perhaps more accurately be seen as the series of economic and societal transformations resulting from the introduction and application of new technological innovations. Of particular importance are the so-called General Purpose Technologies (GPTs), named as such for their broad and transformative potential applications across all fields In aggregate, and especially through their spillover effects, GPTs generate the economic impact that can define an era.

To provide an idea of the caliber of impact that GPTs can have, the most important GPTs in the prehistoric world were the domestication of crops and livestock, the invention of writing, and the wheel. The eponymous Bronze and Iron Ages take their names from the invention of smelting techniques which, following their spread throughout the world, generated enough impact to name entire eras of human civilization after them. During the First Industrial Revolution, the steam engine was the key innovation that allowed for the development of mass manufacturing through the factory system, mass transportation via railroads and shipping, and an economic boom which produced history's most powerful and influential middle class up until that point. Later on, electrification and internal combustion ushered in the Second Industrial Revolution around the turn of the 20ᵗʰ Century, which produced a boom in information sharing, manufacturing, and globalization which lasted until the outbreak of World War One.

The Third Industrial Revolution (3IR), also called the Digital Revolution, has been an age of computerization. Digitization accelerated the ability of our technology to communicate with itself, leading to the first viable computers, then electronics at increasingly small and more sophisticated scales. These scientific and engineering developments laid the groundwork for an era of digitization and digital record keeping which revolutionized the capacity of technology to spread and exchange information. Digital systems enabled globalization to spread an order of magnitude more rapidly than the analog ones they had replaced. By fusing information and communications technology, the Digital Revolution enabled the invention of the internet, the mobile phone, and other key innovations in the field of electronics and telecommunication which, together, made our planet feel smaller than ever.

Continuing Challenges

Liberalization may have cut through the red tape that held back the Indian economy, but it did so as a double-edged sword. Namely, the high levels of growth which India has experienced have not been shared in by all levels of society. Much of the growth which has occurred has resulted from higher consumption by the wealthy, as income inequality between the top and bottom 10% of the population doubled in the decade following initial

reforms.[8] Although the government recently announced that all of India's villages have been electrified, 240 million Indians remain without power, and only 25% have access to the internet.[9] The flip side of this lack of inclusive growth has been a corresponding lack in social protections, or intentional policymaking to address the growing divide between rich and poor. Against this backdrop, the rise of the services sector has been a silver lining in at least one way, as the middle-skill occupations that form the backbone of the services sector such as secretarial work, clerking, and call centers have paved a robust pathway into the middle class. For those who still see in India a land of opportunity, such pathways to social mobility must be broadened in conjunction with expanding social protections for those both in and out of work at all socioeconomic levels.

The services sector may have been responsible for nearly 2/3 of India's growth over the past ten years, but it has not made nearly as great of a dent in India's lack of quality employment, having only contributed to 25% of hiring over the same period. In fact, despite an economy which has produced impressive topline statistics, India has fallen far short of creating enough jobs to keep up with population growth. Out of eight million people joining the workforce every year, fewer than two million jobs are created annually. The remaining 80% of the workforce ends up in the informal sector of India's dual economy, where workers can expect minimal income, little to no social protection, lack of guarantees such as a contract, and a frequently unsafe working environment. The low levels of productivity in the informal sector, which are both a cause and an effect of the lack of capital available in informal enterprise, are also symptomatic of an economy which has failed to create meaningful opportunities for all its citizens. While record rates of unemployment have made headlines in recent years,[10] the official unemployment crisis is but the tip of the iceberg for a much greater employment crisis in which educated youth from reasonably well-off households are the only members of the workforce deemed capable of finding good jobs in the organized sector.[11]

In the modern Indian economy, the groups effectively excluded from the labor force are those for whom discrimination, especially marginalization along social or cultural lines, serves as a barrier to developing either the social networks or the necessary technical skills to participate. This situation is particularly prevalent for women, religious minorities, and members of Scheduled Castes or Tribes (SC/STs), especially in rural areas. Despite the apparent ubiquitous presence of electronic and digital technology in everyday life, less than 30% of India's internet users are women, and only 14% of rural women own a mobile phone.[12] Low accompanying levels of literacy and education are reinforced by the norms of a patriarchal society which encourages gendered divisions of labor that further exclude women from the workforce while promoting beliefs that they are ill-suited to hold technical jobs. For SC/STs and religious minorities, similar literacy, education, and social network

[8] https://timesofindia.indiatimes.com/india/Indias-income-inequality-has-doubled-in-20-years/articleshow/11012855.cms

[9] https://money.cnn.com/2018/04/30/news/india/india-electricity-villages-modi/index.html

[10] https://www.hindustantimes.com/india-news/unemployment-rate-highest-in-45-years-touches-6-1/story-VOxt06G3gCHFXkTf5DUv0J.html?fbclid=IwAR1yFP5iO72q2l8HDpdKxCAgxgBni4T_H64wdwAab-22DDDXBDPmNdrseAI

[11] http://www.ihdindia.org/sarnet/books/IEG_2016_ES.pdf

[12] https://economictimes.indiatimes.com/tech/internet/only-29-female-internet-users-in-india-unicef-report/articleshow/62027590.cms

challenges constrain the ability of these communities to gain the skills and opportunities necessary for economic mobility. As technological competence becomes increasingly important not just for work opportunities, but even for accessing basic public goods and services, India's socioeconomic digital divide will only complicate efforts to promote an equal, just and inclusive society.

A final characteristic of Indian growth in the 3IR has been its rejection of the labor-intensive small-scale industrialization of the past, characterized by the village-level cottage industries movement promoted by figures such as Gandhi, in favor of capital-intensive growth led by major national and international firms. This shift is reflected in India's poor employment statistics, even in an era of rapid growth. The foreign investment which liberalization promoted starting in 1991 only widened an already existing productivity and competitiveness divide between small and large enterprises. Major foreign companies could afford the capital investments necessary to take advantage of the latest technologies, while cottage industries were unable to do so. Over time, this has resulted in a consolidation of the formal sector within these larger companies at the expense of cottage industry, and especially at the expense of rural economies.

While the highly labor-intensive informal sector would seem to refute the decline of labor-intensive work, unorganized labor is in fact far more symptomatic of hidden, unmeasured unemployment among India's lower classes. Due to its fragmented status and lack of access to capital, the informal sector lacks the scale and leverage necessary to adopt more advanced technologies that could increase labor productivity and yield financial and quality of life benefits for its workers. Among the 80% of the workforce engaged in the unorganized sector, two-thirds work in enterprises without access to electricity, using manual labor in the age of the robot. 58% of enterprises within the unorganized sector have less than ten workers, and a full third of informal workers are "reluctant entrepreneurs" who are self-employed in highly labor-intensive fields because they have no other choice.[13]

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[13] http://www.pooreconomics.com/chapters/9-reluctant-entrepreneurs

The Fourth Industrial Revolution
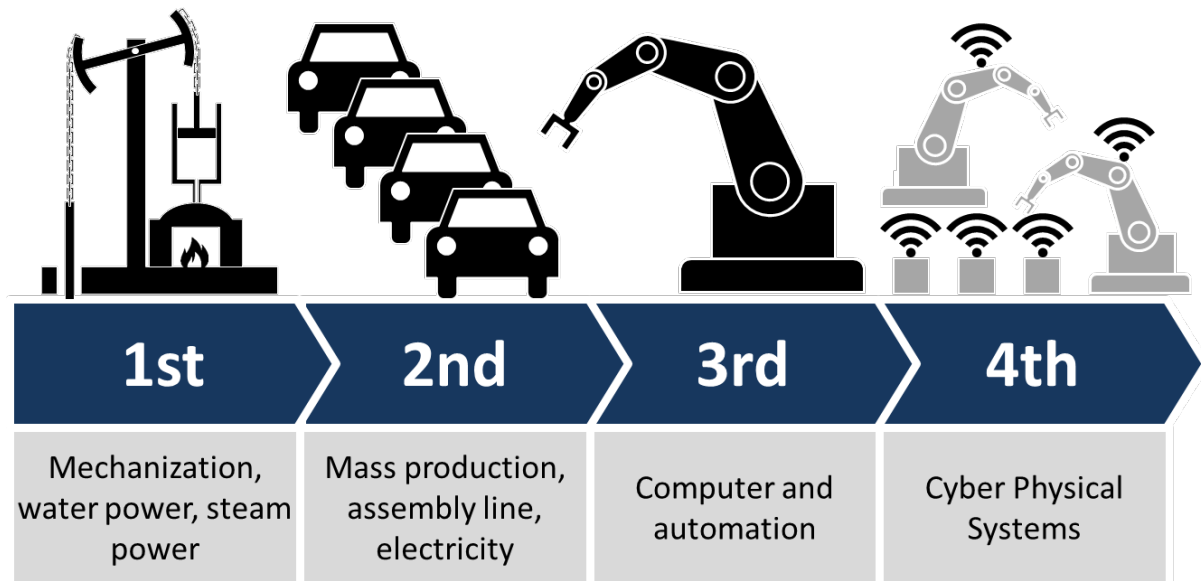
The Four Industrial Revolutions. *https://cellcode.us/quotes/phases-of-the-industrial-revolution.html*

The global 3IR economy was characterized by the widespread adoption and implementation of computing, telecommunication, and electronics, enabling globalization through the virtual elimination of barriers to information and of distance as an impediment to communication. These technologies generated tremendous incremental improvements in the context of an analog world, representing another discrete step in the history of industrialization from manual individual workmanship and direct in-person delivery of services to mass communications and the automation of simple and predictable tasks through basic electronics. By democratizing the production of information, 3IR technologies have also been in part responsible for tremendous social upheaval, with the abilities of social movements to organize, communicate, and mobilize greater than ever before.

The Fourth Industrial Revolution (4IR), which covers the emergence of technologies ranging from machine learning, artificial intelligence, autonomous transportation and cloud computing, has yielded a sea change in economic history by permanently altering the relationship between man and machine. Prior disruptive technologies, from the steam engine to the internet, had heightened the ability of humans to produce goods and services by automating the low-level skills and tasks inherent in that production while leaving people in charge for higher-order management and creative direction. On the other hand, 4IR technologies could cut us out of the equation by doing the thinking for us. In the 4IR economy, which some commentators have referred to as Industry 4.0 or the Second Machine Age, human-designed digital processes will gain the ability to learn from and perfect themselves through constant iterative interaction with data coming from and shared with more sources than ever before. In doing so, through the sheer weight of data provided to them, machines will gain an ability to interact with fluid and unpredictable situations that has long been reserved for human operators, designers and managers. This could leave humans responsible only for tasks related to creativity, management and human

interaction, with robots responsible for the rest. Depending on the sophistication of our algorithms, the distant future could see us cede even these quintessentially "human" roles. We find ourselves at the beginning of an age defined by a group of technologies with the same transformative potential as the wheel, the printing press, and the invention of electricity. Defining our relationship to them, and proactively responding to the changes in society and the economy that they will precipitate, is of paramount importance.

Key Disruptive Technologies

Cloud Computing

Data is the fuel for all digital processes, but especially for the autonomous algorithms of the future that would seek to operate based on their innate knowledge of their own environment. Accurately describing an environment to the degree that a machine will be able to interact with it not just passively, but actively, requires vast amounts of data. Three separate trends have converged to give machines the ability to interface with data, and therefore perform autonomous actions based on information about their environment, like never before.

First, the costs of data storage have dropped to the point where continuously evolving databases of information about our world can be maintained at nearly no cost. This was not always the case. At the dawn of the computer age and through the 1960s, binary information was stored on vacuum tubes which consumed tremendous amounts of power, frequently broke down, required entire rooms for proper storage, and whose storage capacity, for all that, was minimal. Yet the trajectory of the digital age has been one of exponential growth. Moore's Law, a 1965 theory proposing that the number of components per integrated circuit would double every ten years, has held true over the 55 years since its introduction. With the technological advances predicted by Moore's Law has come parallel increases in both processing power and storage capacity. Circuits today require less power, less space, and less time than ever to access the data contained within them. As transistors approach the size of an atom, physical constraints could cause Moore's Law to plateau. On the other hand, advances in Quantum Computing could also allow technology to transcend what are currently considered physical limitations.

The second trend has been the rise of so-called Big Data. Increasing processing power has allowed computers to package ever smaller and more discrete packets of information about every aspect of our environment, while decreasing storage costs have provided the means to store such vast and untargeted quantities of data. With increasingly sophisticated analytics, big data can comprise anything from audio, video, images, text, or sensor readings. Big data has turned creative and innovative processes on their heads. In the sciences, research in a pre-digital world meant proposing a hypothesis, then collecting the specific data necessary to confirm or reject that hypothesis. In other words, data was the constraint. When data about virtually any question is available at a moment's notice, our ability to interrogate our world instead becomes the constraint, meaning that the advancement of knowledge is no longer limited by limitations on the gathering of information, but instead by human ingenuity itself. In the optimistic case, big data provides the information foundation for next-generation translation software, prediction of natural

disasters, and optimization of agriculture. Taking on a darker tinge, big data has also been used to track and target oppressed populations and manipulate elections. Regardless of the application, algorithms eat data for breakfast. Big data, provided it adheres to the three key criteria of volume (quantity of data generated and stored), velocity (rapid enough data generation to enable real-time analysis), and veracity (well-organized, quality data), can offer a solution to virtually any computational problem we can define.

Finally, big data and the internet have come together to make cloud computing viable. Traditionally, while the internet served as a place to browse and exchange information, most actual computing was done offline on local devices. This was the case not only because mass storage and access of data was expensive, but also because transmission of centrally stored data was too slow and costly to be practical. The fragmented digital ecosystem that resulted didn't just place the burden of data storage on end users; it also inhibited the coordination, synergies and economies of scale that have lately become the hallmark of digital technological advancement. Breakthroughs in digital transmission technology have lately made cloud computing not just viable, but the preferred choice for new applications of digital technology. The evolution from broadband to fiber networks has already made cloud computing through fixed internet infrastructure more complex, rapid and efficient than could ever be achieved on local networks. 4G and LTE have started to do the same for mobile networks. As 5G is implemented over the next decade, mobile internet will undergo the same type of revolution. Capable of transmitting up to 10 Gbit/second, more than 30 times faster than the best LTE networks, 5G will provide for effective real-time transmission of data, serving as the key enabling technology for the Internet of Things (IoT) as discussed below.

Cyber-Physical Systems

In many ways, the advent of the Internet of Things is already upon us. Today, everything from our cars to our coffee makers can be outfitted with internet connectivity in order to improve their functionality in some way. These applications are currently most apparent in the domestic market. A navigation device can tap into the network to identify not just the best route to reach a destination, but also traffic along the way and real-time hazards and optimizations. Appliances can be synced up with users' mobile devices to reduce energy usage through remote management. Smart speakers can interpret users' voice commands to answer questions, perform requests, and even place orders.

In reality, the devices that comprise the Internet of Things are situated in an important transitional role. These devices use the technologies of the Third Industrial Revolution, namely electronics and limited automation, and while some of the more advanced examples represent software breakthroughs, few are examples of hardware breakthroughs. However, these simple devices are the early building blocks of a much more expansive and universal digital infrastructure which, in the relatively near future, will enable comprehensive digital interaction with our daily environments. In aggregate, IoT devices will erase a barrier between digital systems and physical infrastructure, a barrier which is arguably the boldest dividing line between the Third Industrial Revolution and the Fourth Industrial Revolution.

This future is coming sooner than we think; by 2021, an estimated one million IoT devices will be purchased worldwide every hour.[14]

The new infrastructure and processes that will emerge from this transition can collectively be termed as cyber-physical systems. Cyber-physical systems apply algorithms, often autonomous or self-improving, to build a digital infrastructure out of the individual data contributions of individual IoT devices. The result is a coordinated ballet between automatic processes that, while fluidly adapting to the fluctuating needs of individual users, manages the demands placed on a system while continuously adapting and optimizing itself. If a self-driving car is an IoT device, a cyber-physical system is a new cloud-based infrastructure that intelligently manages the flow of millions or even billions of vehicles every day in real time. Similar examples can be identified for smart utilities, medical monitoring, and supply chain management.[15]

Cognitive Computing

Early computers were limited in the tasks they could perform by limited capacity for data storage and limited processing power for juggling the variables necessary to answer more complex questions. As hardware has evolved, these processing and storage constraints have receded. Cloud computing offers the prospect of removing them entirely, while big data, which forces us to rethink and expand our conception of what data even is, provides a world of information available for analysis. Thanks to the convergence of these trends, computers are increasingly able to solve the exponentially more complex problems that characterize and even mimic human cognition. This transition into cognitive computing, once universally implemented, could seal the world's entry into Industry 4.0. The applications of cognitive computing, which today range from natural language processing to object recognition, will only grow more sophisticated over time.

Modern cognitive computing applies a technique known as machine learning to design algorithms that attain the complexity required to respond to such complex challenges. Machine learning takes a step in a different direction than computer science as implemented in the 3IR. Historically, computer programs have been written as lists of specific, rigid instructions for machines to follow. In contrast, programs written using machine learning in mind use training data as an input which a computer imitates improvisationally while building a mathematical model to respond to a specified task, without having received specific instruction in that task beforehand. This process mimics the natural biological process of absorbing information, attempting to replicate these inputs ourselves, and making iterative improvements based on feedback about our performance until we are able to satisfactorily complete a task. More advanced applications of machine learning, such as artificial neural networks, further blur the line between the digital and the biological by communicating between nodes in the same matter as the neurons in the brain in order to perform even more complex processes. So-called "deep learning" goes further

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[14] https://www.forbes.com/sites/kinetica/2019/05/31/the-internet-of-things-is-powering-the-data-driven-fourth-industrial-revolution/#2c9a793824e8

[15]

https://www.academia.edu/23178627/Design_Techniques_and_Applications_of_Cyber_Physical_Systems_A_Survey

down this pathway by explicitly modeling the function of the human brain to synthesize light and sound inputs into specific, concrete concepts.

Adapting to New Technologies

Conventional wisdom dictates that automation itself is a threat to the future of work, but exactly what that automation involves is not clearly defined. Throughout the history of industrialization, machinery has been developed to supplement and increase the productivity of human labor. In the short-term, this creative destruction has inevitably led to social disruption and job loss. The invention of the automobile put the vast majority of carriage drivers out of business. While the term *computer* used to respond to human workers who performed repetitive mathematical tasks, it today refers to machines which can complete that job without step-by-step human involvement. In each of these cases, initial job losses were compensated for by global increases in productivity and a reskilling of the work force to adapt to the new labor market that more than made up for the initial negative shock. Why should we expect that the automation we experience in the present day be any different?

The answer is that automation as implemented today, in its most disruptive forms, exists along a spectrum that straddles the 3IR and 4IR. In all prior technological revolutions, including the 3IR, machines grew to perform specific tasks more efficiently than humans could. But humans, with our complex cognitive processes, creativity, and social intelligence, have always been able to retreat to a higher ground where technological progress elevated us, rather than displacing us, by providing room for us to perform different tasks that complemented the work of machines, rather than competing with them. With that being said, there are only so many discrete categories of tasks that are involved in work. As the tide of technological progress and automation continues to rise, mankind may soon find that it has no higher ground remaining to retreat to.
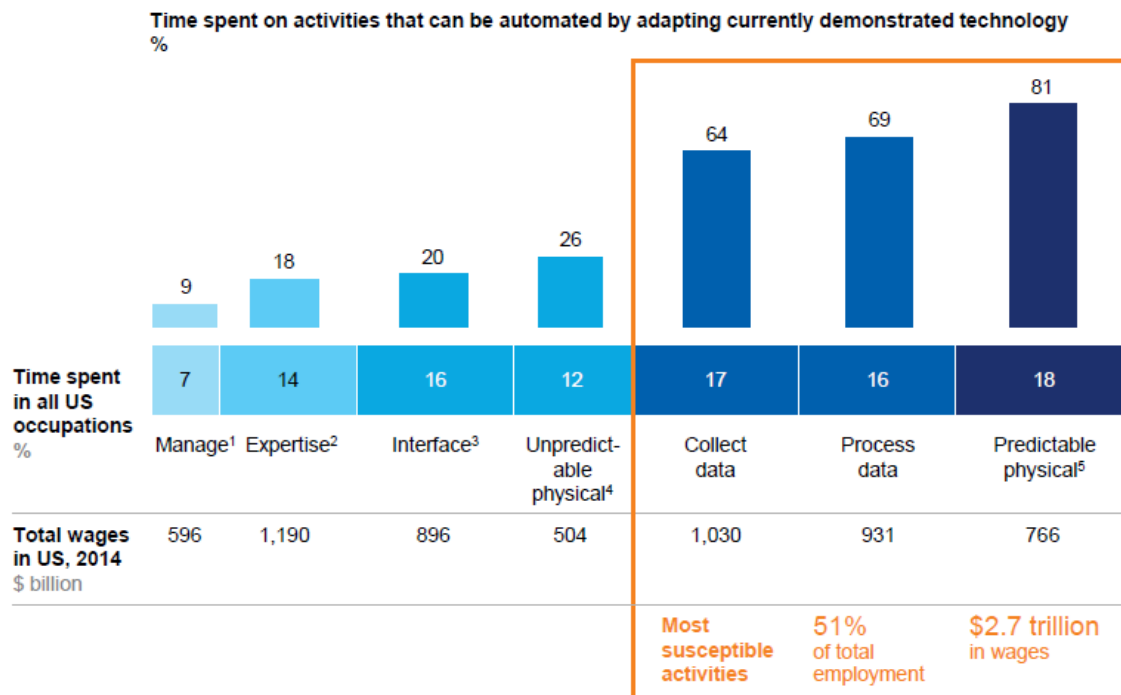
Vulnerability to Automation

In an effort to identify the susceptibility of labor to automation, McKinsey Global Institute identified seven discrete categories of tasks which are performed in work, listed below.[16]

1. Managing and developing people
2. Applying expertise to decision-making, planning, and creative tasks
3. Interfacing with stakeholders
4. Unpredictable physical activities
5. Collecting data
6. Processing data
7. Predictable physical activities

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[16]
https://www.mckinsey.com/~/media/mckinsey/featured%20insights/Digital%20Disruption/Harnessing%20automation%20for%20a%20future%20that%20works/MGI-A-future-that-works-Executive-summary.ashx

MGI also estimated the automation potential of each task within the US workforce on the basis of adapting currently existing technologies. Unsurprisingly, the latter three tasks were the most automatable. In the predictable physical labor segment, a staggering 81% of time spent on work activities could be automated away by implementing technology that already exists.
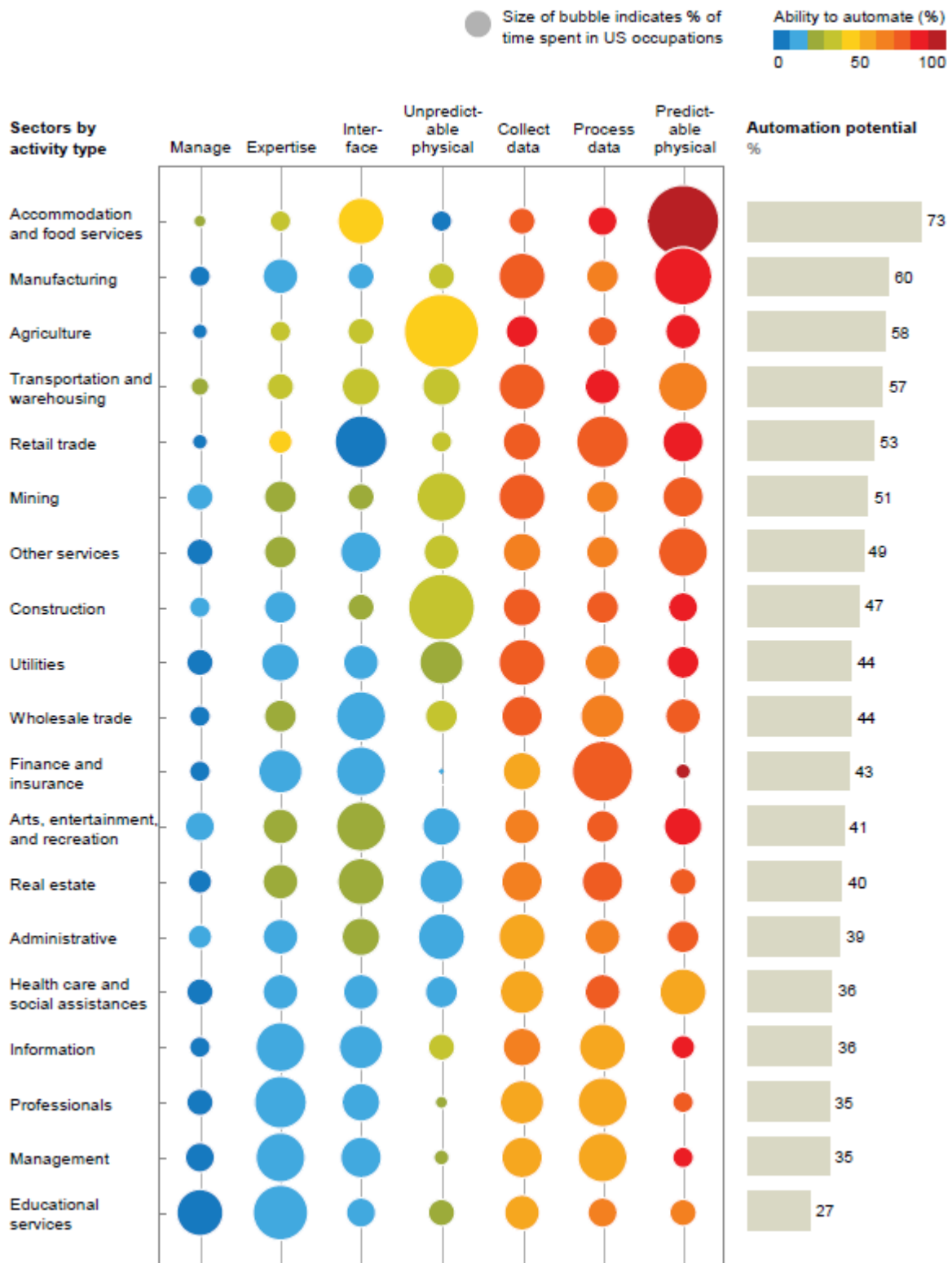
Time spent on activities that can be automated by adapting currently demonstrated technology
%

	Manage[1]	Expertise[2]	Interface[3]	Unpredict-able physical[4]	Collect data	Process data	Predictable physical[5]
(bar value)	9	18	20	26	64	69	81
Time spent in all US occupations %	7	14	16	12	17	16	18
Total wages in US, 2014 $ billion	596	1,190	896	504	1,030	931	766

	Collect data	Process data	Predictable physical[5]
	Most susceptible activities	**51%** of total employment	**$2.7 trillion** in wages

Automation potential by task in the US workforce. McKinsey Global Institute.

Unsurprisingly, the tasks most vulnerable to automation are those that are the most rule-based. Automation in the 3IR focused on rule-based tasks because they carried lower levels of computational complexity. With these technologies having reached theoretical maturity, the only things standing in the way of automation for these jobs are economies of scale, policy barriers, and organization by workers. Economies of scale will provide greater advantage to automation as time goes on, and absent a protectionist push to keep automation out of these jobs that would disadvantage the sectors that try to hold back the tide, they will become largely automated in the near future.

A clear relationship exists between job tasks and automation potential, but this does not correspond to education requirements. This is because while certain tasks require humans to learn many discrete bits of information, they remain cognitively predictable enough for machines to easily perform the same work. The medical field is perhaps the best example of this misalignment between educational attainment and automation capacity. An aspiring doctor would have to train for years in medical school to qualify as a general practitioner, and years more to attain the qualifications necessary to issue diagnoses as a specialist. In contrast, all known data not just about a certain medical field, but also the raw digital data on every patient to have presented with specific illnesses, including nontraditional data such as medical imaging, can be fed into diagnostic programs that have just now started turning the corner to issue more reliable diagnoses than trained professionals. While humans still excel in the social aspects of medical care, such as bedside manner, medical professionals

could otherwise be automated out of existence within the not too distant future. As part of the same analysis, MGI also examined the vulnerability to automation of each sector within the United States, as portrayed below.

Technical potential for automation across sectors varies depending on mix of activity types

Size of bubble indicates % of time spent in US occupations

Ability to automate (%)
0   50   100

| Sectors by activity type	Manage	Expertise	Inter-face	Unpredict-able physical	Collect data	Process data	Predict-able physical	Automation potential %
Accommodation and food services								73
Manufacturing								60
Agriculture								58
Transportation and warehousing								57
Retail trade								53
Mining								51
Other services								49
Construction								47
Utilities								44
Wholesale trade								44
Finance and insurance								43
Arts, entertainment, and recreation								41
Real estate								40
Administrative								39
Health care and social assistances								36
Information								36
Professionals								35
Management								35
Educational services								27

SOURCE: US Bureau of Labor Statistics; McKinsey Global Institute analysis

The sectors most vulnerable to automation are the usual suspects: industries relying on less skilled labor that performs relatively routine tasks. However, some surprises lay further down the chart. Real estate and administrative work are perceived as professional sectors, and arts, entertainment, and recreation is seen as a highly human occupation. Yet these sectors could experience high levels of economic impact resulting from automation of professional expertise and interfacing with clients. The least automatable industries, management and educational services, are not coincidentally the sectors most reliant on individual human interaction and social intelligence.
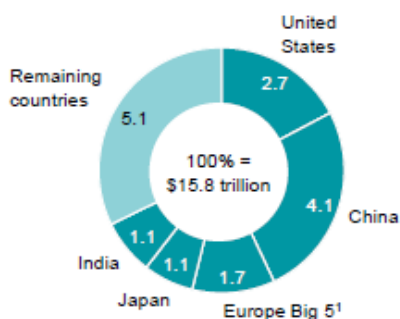
Adaptation in the Indian Context

Employee weighted overall % of activities that can be automated by adapting currently demonstrated technologies

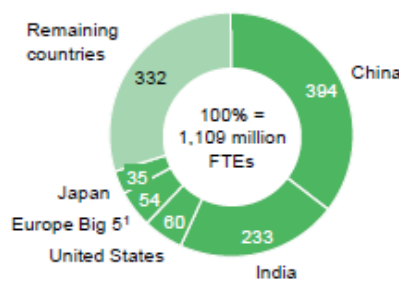| <45 | 45–47 | 47–49 | 49–51 | >51 | No data |
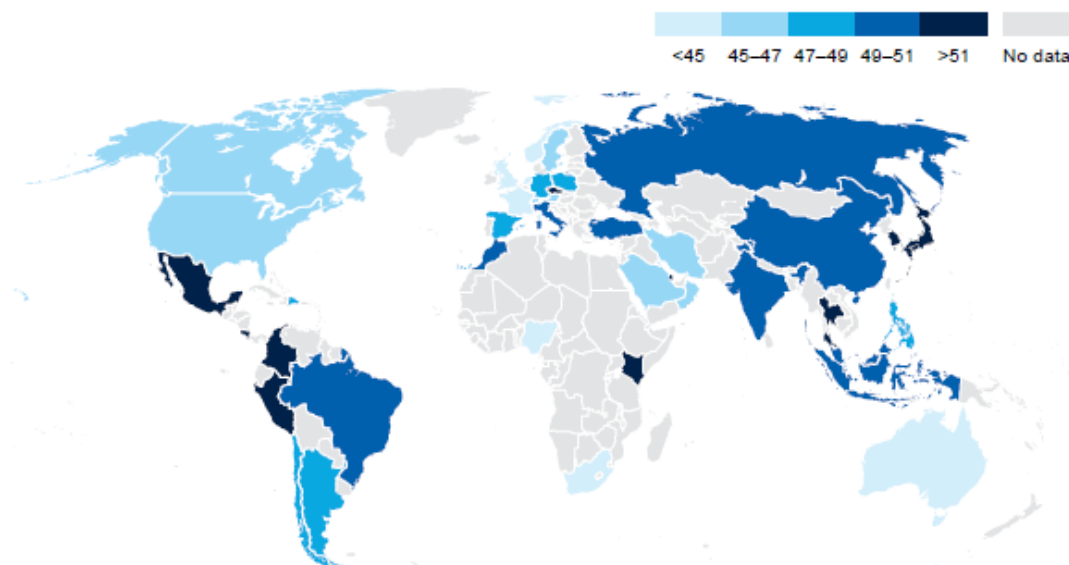
Technical automation potential is concentrated in countries with the largest populations and/or high wages

Potential impact due to automation, adapting currently demonstrated technology (46 countries)
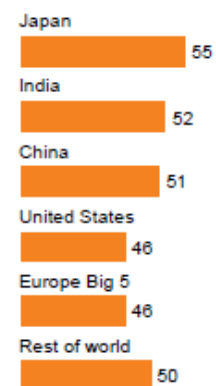
Wages associated with technically automatable activities
$ trillion

- United States 2.7
- Remaining countries 5.1
- 100% = $15.8 trillion
- China 4.1
- Europe Big 5¹ 1.7
- Japan 1.1
- India 1.1

Labor associated with technically automatable activities
Million FTE

- Remaining countries 332
- China 394
- 100% = 1,109 million FTEs
- Japan 35
- Europe Big 5¹ 54
- United States 60
- India 233

Automation potential
%

Japan	55
India	52
China	51
United States	46
Europe Big 5	46
Rest of world	50

1 Pakistan, Bangladesh, Vietnam, and Iran are largest countries by population not included.
2 France, Germany, Italy, Spain, and the United Kingdom.
NOTE: Numbers may not sum due to rounding.

SOURCE: Oxford Economic Forecasts; Emsi database; US Bureau of Labor Statistics; McKinsey Global Institute analysis

In theory, India is as vulnerable to job loss from automation and other 4IR technologies as developed countries, if not more so. The same technologies exist and are available around the globe, so the same type of labor should be exposed to automation. Furthermore, India's workers engage in higher rates of the low-skill tasks that, although they do not correspond perfectly to automation potential, have demonstrated a reasonably high correlation. The MGI automation study pinned the automation potential of Indian labor at 52%, higher than the 46% rate in the US and one of the highest national rates recorded. In a country with such high population growth which is already failing to provide enough job opportunities to its restless youth, and which struggles with both formal and unmeasured unemployment, the prospect of such drastic future job losses should spell disaster.

But India is not a developed country. It does not face the same currents in the labor markets as developed countries, it has not achieved the same levels of technological penetration, and its workers are not as threatened by the arrival of automation as those in wealthier countries. India will still experience significant transitions as new technologies are implemented throughout its domestic market, generating new pressures and challenges which must be addressed through forward-looking, pragmatic policymaking. But in the near future, India does not face the catastrophic scenario of mass unemployment that one might fear.

India's Business-As-Usual Trajectory

In India, the key distinction that must be made is between automation potential and automation adoption. For the reasons outlined above, automation potential is quite high. However, automation adoption remains quite low. The main reason for this is that automation will only be adopted when it is not just viable, but also competitive with traditional labor. Outside of specific niche applications, this is not yet the case in India. Key enabling infrastructure necessary for the introduction of 4IR technologies remains lacking throughout much of India. Access to power and digital enabling infrastructure is frequently unreliable. In the unskilled sectors that comprise much of the Indian economy, such as the agriculture sector, labor costs remain so low as to make investments in costly technologies nonviable, especially given the predominance of unpredictable physical labor in these sectors, a relatively difficult and costly task to automate.

In some respects, investigating the potential for 4IR automation in the Indian context is a moot point when so much of the country has yet to complete its transition through the 3IR. In the agriculture and mining sectors, mechanization has experienced a steady rise, but enterprises within these sectors, especially smallholder farmers, are just now gaining the tools necessary to apply the available data to improve decision making about their own production.

So where is adoption of 4IR technology possible within the near future? Automation has already begun in the capital-rich manufacturing, financial and legal services, and IT sectors, which are consolidated enough and have the economic incentives necessary to support robust investments into new technologies. Beyond the narrow niches where 4IR adoption is viable, though, the best way to predict the future is to examine the correlation between the jobs associated with specific skill levels and their potential for automation.

Future of jobs and its implications on Indian higher education
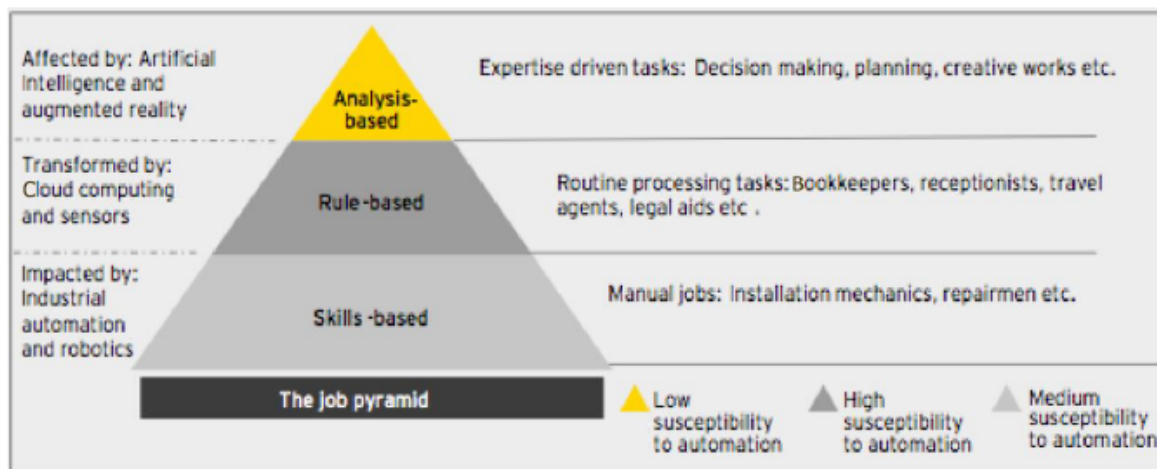
Source: The Federation of Indian Chambers of Commerce and Industry, November, 2016

Formal Sector

The least vulnerable jobs to automation in India given current wage, infrastructure, and capital availability conditions are the high-skill analytical positions which, in developed countries, have begun feeling the heat of 4IR technologies. The bottom of the job pyramid is engaged in the type of labor that is just non-routine and unpredictable enough to stave off automation through the near future, especially given the low earnings of these largely informal workers.

On the other hand, the low-middle skill jobs in the middle of the pyramid, held by cashiers, receptionists, legal aides and other office workers with routine jobs, are highly vulnerable to automation through widely available 3IR technologies. Critically, these jobs have served as a key pathway for youth in the unorganized sector to enter the middle class through formal labor with social protections. The elimination of this pathway could worsen the social instability resulting from a young, rapidly growing labor force already lacking prospects for decent work. The decline of low-medium skill employment has already begun, with the employment share for these occupations dropping from 76.5% in 1993-4 to 70.2% in 2011-12 and the wage share likewise dropping from 70% to 59.4% over the same period.[17] Manufacturing, the sector most exposed to automation of middle-skill jobs, led this decline, and other exposed sectors such as IT are likely to follow to the detriment of India's aspirational poor. For the 40% of New Delhi's youth population aiming to become software engineers, now would be a good time to consider rethinking their career plans.[18]

Informal Sector

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[17] https://think-asia.org/bitstream/handle/11540/7025/Working_Paper_334.pdf?sequence=1
[18] https://economictimes.indiatimes.com/jobs/about-39-of-youth-in-ncr-aspire-to-become-software-engineers-survey/articleshow/57518235.cms.

3IR automation within the middle-skill jobs that traditionally help Indians chart a path into the middle class poses a serious threat to economic opportunity and generational social mobility. But with that being said, the sectors with the highest anticipated rates of adoption are not major employers in the overall economy, so the impact on workforce participation will be minimal. For the 80% of the Indian workforce in the informal sector, experiencing low wages, poor working conditions, and lack of formal social protections in their largely unskilled employment, automation is not the most relevant facet of the future of work. Instead, the rise of the on-demand platform economy, backed by the emergence of 3IR mobile technology, is what these workers should be paying attention to.

By 2020, India is expected to become one of the global leaders in the platform economy, accompanied by the United States and China. The reasons for this are threefold. First, a rapidly expanding and technologically literate urban consumer class is increasingly demonstrating preferences for ordering goods through the on-demand economy. Second, contract labor is on the rise in relation to wage work as a cheaper and more fluid alternative allowing employers to shift employees according to need while evading responsibility for providing fringe benefits. Finally, the platform economy offers inroads for isolated and excluded groups, such as recent migrants and women, to land more meaningful economic opportunities.

Yet the digital gig economy, just like in the developed world, is a mixed blessing. Certainly, for the vast majority of informal workers likely to participate in it, it's an improvement over the status quo. Informal workers can already be seen as participating in a type of gig economy where no job is secure, multiple opportunities must be chased at once to earn a living, and formal social protections are nonexistent. Independent contractors working on digital platforms will gain some of the benefits of formalization they would otherwise completely lose out on, such as access to banking and flexible hours. Yet the innate lack of transparency and power imbalance between employer and employee embodied in the platform economy results in unfair and often manipulative contract systems that effectively replicate the precariousness of unorganized labor.

Just as ICT tools have been used to reproduce the injustices of India's labor market, the same tools can be used to organize employees and bargain for working conditions that more closely resemble a decent job. Platforms can aggregate contractors both within and across various service providers to form communities with potential to engage in collective bargaining. User data made available on these same platforms can reinforce bargaining efforts by adding to the transparency that can aid in negotiations for fair pay. But for more structural reforms that will prevent the platform economy from becoming another manifestation of India's dual economy, policy interventions will have to take place to secure formal benefits, social protections, and job security.

Policy Recommendations

Formal Protections in the Digital Economy

The platform economy which India's informal urban workforce increasingly participates in certainly represents an incremental improvement over the complete insecurity of unorganized work, but workers in the gig economy are still far from engaging in the kind of decent work promised in Sustainable Development Goal 8. Workers for these platforms are overwhelmingly not accustomed to the protections they have a right to, having come from the informal sector, but since the platforms themselves operate entirely within the formal sector, the government has no excuse not to develop new regulations to enforce improved working conditions in the evolving digital economy. Required policy measures include access to formal social protections like the Provident Fund, collective bargaining rights, grievance mechanisms, and contract and pay transparency. Platform workers can kickstart this advocacy process by leveraging ICT themselves to organize, share information and complaints, and begin the process of collective bargaining. If such efforts are successful, the platform economy should be encouraged to expand and more thoroughly formalize the unorganized sector.

Redistribution of Technological Gains

The digital revolution has been and will continue to be responsible for rapid productivity gains and explosive earnings growth for the owners of the technologies in question. Without proactive, assertive and conscious policymaking, though, these gains will not be shared with the rest of an already highly unequal society. If these gains are shared inclusively, they could finance sweeping social programs such as universal basic income, free universal healthcare, and expanded higher education to both improve the welfare of the general population and to increase the average Indian's likelihood of participating in the new economy. Notable international proposals for redistributing technological gains have included Bill Gates' robot tax and redistributing employment itself by limiting weekly hours per employee.[19] The most probable current approach in India is NITI Aayog's proposed labor utilization fund, which would issue grants to increase workforce skill levels and competitiveness to businesses considering automation.[20]

Re-Skilling and Up-Skilling

Skilling initiatives are the classic response in developed nations to industries facing disruption or displacement, and they have their place for younger workers who have not tied their identity and sense of self-worth to their specific job in the way that older workers often do.[21] Yet a single pass is insufficient, given the continuous disruptions that will take place as 3IR and later 4IR technologies fully take hold in India. Young people entering the workforce today are likely to work for as many employers as their parents held job titles, meaning that incubating a culture of self-improvement and lifelong learning is critical for mitigating the inevitable turmoil from these disruptions. Education initiatives should be expanded to be made accessible to not just youth, but also adults of all ages who could potentially engage in the workforce. As 4IR technologies make specific job tasks obsolete

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[19] Pedro S. Rapaso and Jan C. Our Van. 2008. "How working time reduction affects employment and earnings." *Institute for the Study of Labour, September, 2008.*
[20] http://www.livemint.com/Politics/X02BkYjgt76mstRasNrEiI/NITI-Aayog-proposes-scheme-for-saving-jobs-from-automation.html
[21] https://www.economist.com/special-report/2017/01/12/retraining-low-skilled-workers

over the medium to long term, education efforts should focus on creativity, critical thinking, problem solving, and interpersonal management, the skills most resistant to automation.

Management of Technological Trajectories

The free market has been the main driver of automation and 4IR innovation, but it can not be expected to innovate technologies to address India's most challenging and intractable development challenges. Not applying the immense energy and potential of a new Industrial Revolution to bend India's development trajectory would be a tragic waste. Fortunately, policy can play a role in shaping these incentives. Policies have already been rolled out to support 4IR adoption in the health, agriculture and education sectors. These efforts can be improved upon by expanding them from individual patchwork solutions into a mutually reinforcing experimental network that learns proactively and takes the lead in establishing the foundations of a hard and soft digital infrastructure. Through a comprehensive approach that implements 4IR best practices, as identified through thorough experimentation in the field, across all domains of sustainable development, India can leverage the new technological revolution not to divide its population, but to ensure an inclusive society for all.

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