

ARTIFICIAL INTELLIGENCE REVOLUTION IN INDIA

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Abstract

Recent advances in artificial intelligence (AI) are a wake-up call to policymakers in India, with every one of Prime Minister Narendra Modi's flagship programs likely to be directly affected within the next few years. With China making rapid progress in AI-based research, it is imperative that India view AI as a critical element of national security strategy. Spurring AI-based innovation and establishing AI-ready infrastructure are thus necessary to prepare India's jobs and skills markets for an AI-based future and to secure its strategic interests. AI-based applications to date have been driven largely by the private sector and have been focused primarily in consumer goods. The emergent scale and implications of the technology make it imperative for policymakers in government to take notice. In this article we discuss about the Early lessons of AI success in the United States, China, South Korea, and elsewhere offer public and private funding models for AI research that India should consider. The sequential system of education and work is outdated in today's economic environment as the nature of jobs shifts rapidly and skills become valuable and obsolete in a matter of years.

Keywords : Artificial intelligence, national security, jobs and skills, private sector, private funding.

1. Introduction

Recent advances in artificial intelligence (AI) have stimulated fervent interest from both the private sector and governments across the globe, as the possibility of mass-produced consumer product machinery with humanlike intelligence inches closer to reality.

The big breakthrough for artificial intelligence in recent months was the victory of machine over human in the ancient board game Go. AlphaGo, an AI-based computer developed by London-based Google DeepMind,[1] challenged the world champion of the Chinese board game, Lee Sedol of South Korea, to a series of five games in which the machine defeated the human four to one. While AlphaGo deservedly captured headlines across the globe, the real breakthrough in artificial intelligence is not this singular event but the impressive advances artificial intelligence-based computer programs have made as a technology, to the point that they can learn and intelligently respond across a wide range of problem domains.

2. Objectives

1. What are the AI-based applications?
2. What are the Global lessons in relation to AI in India?
3. What is the AI impact on Indian Jobs?
4. What are the challenges and opportunities of AI?

3. AI-based applications

AI-based applications today have already touched people's lives in ways that are often not fully perceived or fathomed. Until now, this subtle proliferation of AI technology has been driven largely by the private sector and has been focused primarily on consumer goods. The technology, however, is of such great potential and importance that its development and implementation cannot be left solely to a few Silicon Valley corporations and their distributors: the emergent scale and implications of AI's applications make it imperative for policymakers in government to take notice.[2]

To better appreciate how AI's propagation has affected people's lives, consider the following examples. Every time someone visits a website, a network of algorithms running in the background processes the data of the user's online behavior: analyzing the browsing history and collapsing thousands of data points into an intelligent guess on which products would entice the user, all in order to decide which advertisements to display. From the intelligent keyboards on smartphones, which reduce a user's typing burden by anticipating the next words, to the voice-activated assistants in tablets and desktops, capable of following voice commands and completing follow-on tasks, the machines in users' immediate personal space have become far more intelligent than is commonly realized.

While there is a substantive body of literature on recent advances in AI and the resulting implications for jobs, skills, and society at large, few analyses have examined the specific impact of AI on India's emerging economy. The Indian government is aggressively trying to increase human capital on a national scale, with a specific emphasis on its younger population through the Skill India initiative, while seeking to attract global manufacturing to India via its Make in India program. The other part of this modernizing triad is the Digital India initiative: a determined push to expand digital access nationwide. AI will have a direct impact on each of these flagship initiatives of Prime Minister Narendra Modi in the immediate future, making it all the more urgent for policymakers in India to take seriously AI's potential for national strategies and to be on the front line in developing AI technology.

For India to maximally benefit from the AI revolution, it must adopt a deliberate policy to drive AI innovation, adaptation, and proliferation in sectors beyond merely consumer goods and information technology (IT) services. AI's rapid diffusion begets unique opportunities and challenges for India: establishing policies specifically designed for the short term and tailoring

the Modi policies to incorporate and emphasize AI, as well as for the medium and long terms, will allow India to appreciate the technology's full potential. While India has undoubtedly been a benefactor of AI's rapid ascent, AI has yet to capture the imagination of the country's policymakers. In foregoing the opportunity to inaugurate national strategies concerning AI, India runs the risk of falling behind the United States and China. AI technology has enormous potential to shape India's economic and national security future; in the absence of a specific policy regime, however, India will find it difficult to realize the full power of AI while potentially falling prey to the detrimental effects of AI proliferation.

Before addressing the challenges and opportunities for India, it is critical to understand what has changed in the field of AI in recent times. The answer lies in what experts of the industry refer to as Moore's law and its broader impact on the computing space. This maxim states that the number of transistors in computer chips doubles every two years, meaning that computer power increases and the relative cost of computer hardware decreases at an exponential pace; the fruit of this relation—faster and cheaper computing power coupled with the diminishing size of computer hardware—has had a decisive impact on AI. The faster, smaller, and less expensive hardware available today enables the computer algorithms of the 1990s to solve far more complex problems than they were previously capable of handling. In this, the profit of Moore's law is obvious: by merely saving time and space, without even accounting for significant improvement to software, computers can perform far more complex operations, creating a multitude of possibilities for advancements in AI.[3]

This efficiency is compounded by the proliferation of cloud technology: with the massive computing power available on demand via cloud-based computing platforms, again at a much lower cost, it is possible today to store and analyze expansive sets of data, potentially processing billions of data points in a matter of seconds. This allows for several layers of computers working in tandem to interpret information in these large data sets, recognizing patterns, discerning behavior, and making intelligent decisions. It has also allowed these computers to learn from their own past performances so that they can improve their capabilities in recognition and deduction.

The combined impact of superior hardware, cloud-based on-demand computing, and the increasingly ubiquitous analysis of big data has spurred significant improvement in the performance of machine learning—the ability of computers to learn without being explicitly programmed.[4] A variety of techniques such as supervised learning, unsupervised learning, and reinforcement learning have become increasingly common in commercial business, leading to consumer applications like Apple's Siri and Microsoft's Cortana.[5] It has also resulted in the viability of complex architectures known as deep learning or deep neural networks, paving the way for recent innovations like the AlphaGo computer.[6]

Given the technology's rapid propagation in the commercial space, it would not be an exaggeration to suggest that the Indian consumer is far ahead of the Indian state in the use of AI. Thanks to the increasingly digital economy, fueled by improving education and globalization, the

Indian consumer is unknowingly the country's biggest beneficiary of recent advances in AI. From utilizing various applications powered by artificial intelligence to using a range of online services such as Amazon Marketplace and Netflix that learn from consumers' online behavior to make intelligent product and service recommendations, consumers are readily engaged with the proliferation of AI in India, whether they appreciate it or not. Policymakers, meanwhile, lag behind, not exploiting AI for national security, public services, or other priorities.

While technologies such as genetically modified foods have prompted sharp public debates in India and drawn the attention of bureaucrats and political parties, AI-powered applications and services have quietly become widely available to Indian consumers thanks to the global digital economy and relatively few barriers to their ensconcing without much political consideration. Indian academics, public researchers, labs, and entrepreneurs face a different challenge than the corporations that dominate the space, however, as the infrastructure necessary for an AI revolution in India has been neglected by policymakers.

For example, cloud-computing infrastructure, capable of storing the vast amounts of data and possessing the massive amount of computing power required by AI, largely resides in servers beyond India's borders. From the Amazon Web Services (AWS) elastic cloud to the Google machine learning infrastructure, almost all of the online tools that have made AI accessible to the entrepreneurial community rely on infrastructure that exists outside of India. A 2016 study on the entire data center market in India estimates its value at \$2 billion—a stark contrast to the \$17 billion of Amazon's last-quarter global revenue from AWS.[7] It is only recently that cloud infrastructure providers have made efforts to invest in this technology in India: Microsoft has pledged to invest in three data centers for its Azure cloud infrastructure, and Amazon has promised to locate some of its AWS infrastructure in India in 2016.[8] This delay in investment has had an injurious effect on the Indian business community, as a number of Indian start-ups have incorporated themselves outside of India in no small part due to easier access to cutting-edge technology and infrastructure with the simplicity of doing business abroad offering a further incentive for corporate flight.[9]

Furthermore, the absence of a large native-install base of on-demand cloud-computing infrastructure in India puts most recent advances in AI out of the reach of government-funded research labs. Perhaps even more damagingly, many industries cannot risk storing their data outside of India and being accessed by algorithms over which the Indian government has little direct control. This constraint makes adoption of AI technology all the more expensive for the private sector. Without this critical infrastructure, India has struggled, and will continue to struggle, to reach the inflexion point in AI efficiency and productivity, all while consumer adoption marches ahead.

Baidu's advancements in AI are the result of ambitious investments in homegrown infrastructure, an institutionalized approach to research, and an innovation ecosystem that extends from Beijing to Silicon Valley—all strategies that to some extent are lacking in India. Baidu's innovation will repay and further this investment in infrastructure, as it has released code

of its deep-learning algorithm for speech recognition to the general public. As other organizations improve the technology and appreciate the benefit of public access, China's homegrown infrastructure and research and development ecosystem will advance further.

Baidu's investment in AI research exposes the relative backwardness of India's technological infrastructure: China has recognized the importance of bridging the gap between the lab and the market while nurturing a research and innovation ecosystem unbounded by national borders and corporate firewalls. India, in contrast, boasts neither the material nor the cultural institutions required for such innovation.

Prime Minister Narendra Modi often challenges Indian IT entrepreneurs, asking when India will give birth to the next Google or Microsoft. But until India attains the infrastructure omnipresent in the United States, and increasingly existent in China, the deep-learning capabilities necessary to address the vast linguistic diversity across India using machine intelligence may prove elusive. Consequently, the policy focus in India should be not only on the creation of an Indian Google but also on the organizational structure, facilities, and customs required for these technological leviathans.

4. Global Lessons for India

Research in AI across the globe has a long history of public funding with periodic cycles of hope and despair. In the past two decades, however, with the advent of the Internet economy, there has been a significant shift toward private-sector funding. An interesting aspect of this shift has been the attrition from academia to industry as major Internet companies have drawn talent from universities to put private-sector AI efforts on a fast track. Indian policymakers intent on spurring AI research will have to look closely at global lessons from both models.

Much of the early support for and investment in AI in the United States came from the government, which was seeking to use machine intelligence to autotranslate Russian documents during the Cold War. These efforts hit a wall in the 1960s after achieving only meager progress; as a result, AI underwent its first winter—reduced funding—after \$20 million in public spending dried up, halting research and stalling scientific impetus.[10] Meanwhile, in the United Kingdom, AI research was virtually abandoned in the 1970s after the Lighthill report, which was commissioned by the British Science Research Council to evaluate AI progress, cited its utter failure to achieve its grandiose objectives.[11] Similar funding cuts by the Defense Advanced Research Projects Agency (DARPA) in the United States prolonged AI's long winter. The 1970s failure of a speech recognition project at Carnegie Mellon University prompted DARPA to cancel a multimillion-dollar research grant, a particularly prominent setback. Similar debacles occurred in the 1980s and 1990s as LISP, an early family of computer programming languages, failed to take off and expert systems gained little commercial traction.

Yet AI research ultimately not only survived but also thrived, as AI applications found their way into embedded systems within other applications as well as standalone technologies. Much of the

public funding for AI in the past decade has come from DARPA's Cyber Grand Challenge, a competition with prize money, and the European Union's EU-FP7 technology funding program.[12] The BRAIN Initiative, created in 2013, is a ten-year, multibillion-dollar fund for AI research in the United States, while the EU's Human Brain Project envisages spending 1 billion euros on AI over the next decade.[13]

The commercial advancements in AI in recent years have come primarily from the private sector, with the labs of Google, IBM, Microsoft, and Facebook proving to be especially fruitful. While the United States and Western Europe enjoy innovation clusters in Silicon Valley, Boston, and London, as well as a network of elite research universities driving private research, India, bestowed with none of these resources, must turn to the public funding approaches employed elsewhere in the world.

For example, South Korea recently announced an \$840 million public-private partnership spanning six corporations to drive AI research and innovation,[14] all in the name of building a "platform for intelligence information society," as reported by KBS World Radio. This follows South Korean investment in projects such as Exobrain, a brainstorming tool, and DeepView, a molecular graphics program, alongside AI initiatives by Samsung, LG, and AI-based news provider KakaoTalk.[15] Even Australia, a Western nation in all but its geography, has directly invested in AI rather than relied on its considerably advanced private sector to spur growth. The country's intellectual property rights agency pioneered the integration and innovation of AI in the public sector in its trial of and collaboration with IBM's Watson.[16] Public funding for AI has even transcended borders: the Malaysian government's strategic investment fund recently invested in an augmented reality/visual recognition start-up founded by an Indian-origin entrepreneur with offices in Silicon Valley.[17]

Privately funded research in AI in India is relatively novel in comparison.[18] Infosys, for example, recently announced its decision to support AI research efforts at the Indraprastha Institute of Information Technology, Delhi, apart from its commitment to open-source AI research efforts led by SpaceX founder and Tesla Motors CEO Elon Musk (and others) under the OpenAI Project.[19] With Arya.ai and just a handful of other Indian AI start-ups beginning to make their mark domestically,[20] India has yet to see its private sector make a significant global impact in AI.[21]

In recent years, the Indian Institutes of Technology (IIT) have largely carried out publicly funded research in artificial intelligence. The most comprehensive insight into the state of AI research in India comes from a 2012 paper for AI Magazine by Deepak Khemani, a professor of computer science at IIT Madras.[22] According to Khemani, AI research in India has been limited to a handful of passionate researchers and thus has significantly lagged behind the United States and Europe. Listing the few labs dedicated to AI at various public institutions of higher education and research, Khemani underscores the limited focus of AI research in India on what he calls societal needs. He argues that because of India's vast linguistic diversity, most research effort

has been applied toward machine translation, natural language, and text- and speech-related applications.

Indian AI research in defense is housed under the Defense Research and Development Organization, specifically within the Center for Artificial Intelligence and Robotics (CAIR).[23] CAIR lists artificial neural networks, computer vision, and situational awareness as its areas of primary focus, mentioning two other products that are under development for network-centric operations and decisionmaking using a vast knowledge base of battlefield tactics data. CAIR also lists civilian applications such as experimental robots, including a machine that can play chess by leveraging an AI-based decision engine.

The debate in China over public funding for AI should be of great interest to India, for the funding's audacity and the scale of its ambition, and even more so for its model of publicly funded AI research. In what appears to be a Hollywood script on "pre-crime"—a term coined by a science fiction writer to describe a police focus on yet-to-be-committed crimes—the Chinese are leveraging predictive policing to profile individual behavior and to predict crimes and terrorist incidents (or as the Chinese prefer to call them, security events).[24] The most definitive insight into the scale of Chinese ambition comes from recent comments by Pan Jianwei, a professor of quantum physics at the University of Science and Technology of China.[25] Speaking in Beijing during the National People's Congress, he called for China's adoption of a DARPA-style defense research funding model that prioritized engagement with the private sector and universities. The joint research by Alibaba and Pan's team in quantum computing and artificial intelligence, a program designed to replicate and surpass Google's DeepMind, is but one example motivating this drive toward commercial and university engagement.[26]

The antiquated model of defense research employed by India has repeatedly struggled to bring research ideas from the lab into the real world, with several critical projects that have been pending for decades. Other developing nations have utilized public funding to advance their domestic AI regimes. But India's defense and other discretionary research apparatuses have yet to take a quantum leap to match China's progress, fueled by the lessons of the DARPA experience.

5. Understanding AI's Impact on Indian Jobs

One unintended consequence of AlphaGo's victory over Lee Sedol is the fear taking root within the popular discourse over job losses to technology.[27] Reported numbers in early 2016 from the Indian information technology industry hint as to how AI-influenced automation is beginning to make an impact on Indian jobs: a recent interview with Tata Consultancy Services' CEO on the projected decline in hiring by major Indian IT companies attributes much of this anticipated downturn to automation, with software replacing employees even as enterprises see greater use of bots and robots.[28]

The IT services sector is not the first to see a deleterious impact from AI on jobs. Manufacturing was arguably the first to bear the consequences of what has been dubbed the second machine age or fourth industrial revolution. While India dreams of its own manufacturing revolution through Modi's Make in India program, it is important for policymakers to closely examine how the advent of industrial robots and their impact on manufacturing transformed companies in other developing nations. The case of Foxconn, one of the world's largest contract manufacturers for electronics, is thus instructive.

The rise of Foxconn is a reflection of China's precipitous ascent as the manufacturing locus for much of the world's consumer electronics, as the company has twelve factories in nine Chinese cities. In 2015, Foxconn made news when its CEO predicted that 70 percent of all manufacturing in Foxconn's assembly lines would be automated with robots displacing humans.[29] Some backpedaling later, his estimate was scaled down to 30 percent.[30] The numbers, however, were irrelevant: this radical transformation in manufacturing, automation through the use of industrial robots, signaled an epochal revolution.

Foxconn is among the top owners of robotics patents filed with the United States Patent and Trademark Office and produces thousands of industrial robots a year that in aggregate are capable of performing more than ten types of manufacturing tasks.[31] This is expected to have a significant impact on the workforce: as many as 60,000 workers have been displaced by robots in one Foxconn factory alone in the Kunshan region of China.[32] China is projected to have more installed industrial robots by the end of 2016 than any other country, with more than 30 robots for every 10,000 industrial workers. If China were to increase that density, employment would be further damaged.

China may well be the last major world economy in which mass job creation from manufacturing is possible, with robots for manufacturing automation becoming increasingly ubiquitous.[33] While the dire predictions of a robot takeover of manufacturing have not come to pass, the reality of automation is that manufacturing is unlikely to create jobs at the scale that it did in the past. Quoting the U.S. Bureau of Labor Statistics in 2013 on future employment projections, Darrell M. West of the Brookings Center for Technology Innovation highlights how jobs will decline over the next decade in manufacturing and information technology among other sectors. "One business leader I know had 500 workers for his \$100 million business and now has the same size workforce even though the company has grown to \$250 million in revenues," West wrote. "He did this by automating certain functions and using robots and advanced manufacturing techniques to operate the firm." [34]

Despite the perils to manufacturing, the nascent debate on the skills and jobs crisis of the AI revolution until now has focused disproportionately on the importance of Indian IT companies building AI-related skills and capabilities and on the need to train Indian IT workers with AI skills to service the next wave of enterprise IT automation in the West. In a repeat of Y2K e-commerce and Web 2.0 waves, the needs and demands of the global IT services market have mistakenly driven much of the focus of Indian IT on AI and machine learning.[35]

Writing in Pacific Standard magazine, Frank Levy, professor emeritus at the Massachusetts Institute of Technology, places jobs dislocation on account of artificial intelligence in perspective when he dismisses the dire projections of a robot takeover.[36] According to Levy, the greatest area of concern for policymakers ought to be the impact of AI on jobs in the middle-skill category—assembly line workers, clerical workers, and the like. Levy also warns of significant dislocation caused by automation leading to a reduction in an individual's potential for upward mobility. Expanding further on what it will take to survive this mass dislocation, he emphasizes that a good education will be critical to acquire the necessary skills and to be competitive in this evolved labor market.

In their book *The Second Machine Age*, Erik Brynjolfsson and Andrew McAfee make several specific policy recommendations for coping with the job crisis likely to be spurred by AI.[37] One such key recommendation of particular importance for India, given Modi's Startup India initiative, is the need to "restart startups." Brynjolfsson and McAfee view creative destruction inherent within the start-up economy as the best bet for experimenting with the new jobs and industries that can thrive in an AI-driven economy. Expanding on the concept of a "peer economy," in which algorithms and machines collaborate with humans to create economic value, the authors provide examples of start-ups such as TaskRabbit and Airbnb that contrive previously nonexistent economic opportunities for ordinary people with spare time and assets, thus creating economically productive work.

Though this volatility in the middle-skill labor market represents perhaps the most profound danger to the new economy, there exists a more subtle danger within the AI community itself. According to the Economist, Uber recently hired 40 of the 140 staff engineers at the National Robotics Engineering Center at Carnegie Mellon University to work on a self-driving car.[38] Examples of flight to the private sector are rife in the United States, as universities continue to struggle to retain talent, especially for researchers and academics studying the in-demand machine learning. The result, according to the Economist, is that AI talent is increasingly and disproportionately concentrated in a few private corporations that have the ability to pay the most.[39] If all AI talent is thus concentrated, then AI research may not be as diversified, and research priorities could be narrowly focused on a few commercial ideas while many areas of social and national importance could suffer for want of talent. This could slow the proliferation and innovation potential of AI, which could displace any number of middle-skill jobs but then fail to create new jobs to replace them. This stagnation would represent the worst possible outcome, as market forces could allow a wealthy AI elite to prosper while stifling competition from start-ups, nonprofits, and institutions focused on the progression, rather than profitability, of AI technology. Were this to happen, the panacea offered by Brynjolfsson and McAfee would be rendered irrelevant.

However, this crisis is hardly inevitable: one effort to open up AI for the common public good is the nonprofit OpenAI, a group led by Tesla's Musk. India's Infosys is among many major IT companies that have joined the OpenAI effort. Though India does not suffer from a brain drain

of top-quality AI talent from university research labs to the industry, it must be wary to avoid this concentration of intellectual energy.

Not everyone is as sanguine as Erik Brynjolfsson and Andrew McAfee are regarding the coming AI revolution. The recent victory of AlphaGo over the world champion in Go has prompted fears of the threat posed by intelligent machines that are capable of superhuman tasks.[40] The direst warning comes from noted physicist Stephen Hawking, who apocalyptically predicts the end of the human race with the development of “full artificial intelligence.”[41] While this doomsday scenario is many decades away, in a recent Guardian profile about the DARPA Cyber Grand Challenge on autonomous hacking to detect and fix cybersecurity vulnerabilities, Konstantinos Karagiannis, a technology executive with a telecom firm, raised the red flag of the likelihood of criminals acquiring AI capabilities to mount sophisticated cyberattacks.[42] In another recent column in the Guardian, Jason Millar, a robotics ethics expert, while calling for an interdisciplinary effort to frame ethics standards for robots and AI, raised the possibility of the “loss of human control” likely to result from advances in AI.[43]

Anxiety over AI mirrors fears over advances in cloning, genetically modified foods, nuclear weaponry, and other areas of technology. The politics over technologies such as AI in India could see a repeat of the kind of protests against the use of computers in machine tools in the 1960s and banking in the 1980s. Indeed, India would have lost out in connecting 1 billion people through cellular telephony if fears over radiation had delayed the rollout of mobile services in the 1990s. Today, through the Aadhaar universal identification program, India's poor have an identity and, overcoming barriers and bypassing middlemen, are empowered to claim their entitlements. This would not have been possible if fears over privacy had stalled the rollout of Aadhaar over the past seven years. Likewise, the AI opportunity in India today should be seen in a similar light as a means for India to not merely leapfrog into the future but also as a means to empower its population.

In the provocative *Humans Need Not Apply*, Jerry Kaplan, a U.S. computer scientist and futurist, explores this and several other questions while attempting to paint a picture of an apocalyptic future and what it might look like if and when machines take over.[44] (Fortunately, that futuristic scenario need not be a concern yet because Kaplan rules out this happening anytime in the immediate future.) Of greater interest is his devotion of specific attention to the immediate challenges and opportunities at hand with the evolution of machine intelligence.

Specifically, Kaplan raises two issues that should be of interest to policymakers in India. The first is the education system and the second involves skills and jobs. While discussing the likely impact of AI on labor markets, Kaplan poses the radical question: Is the current system of sequential education and work outdated, and does it require an overhaul? According to Kaplan, the sequential system—as he put it, “First you go to school, then you get a job”[45] made sense in an economic era in which an individual was expected to hold a single job throughout a career. In an economic environment that is rapidly changing, however, the nature of available jobs constantly shifts, with skills becoming valuable and obsolete in a matter of years. This is not a

reality of a distant future—it is already happening, including in India. The number of engineering graduates who perform jobs distinctly unrelated to the engineering they specialized in and the number of arts and commerce graduates in business processing outsourcing jobs is proof of this phenomenon. A few generations back, a mid-career change in profession was unthinkable; today, several career changes within a span of two decades are routine as individuals reinvent themselves to adapt and stay relevant in a fast-changing economic environment.

Jerry Kaplan's question on the sequential system of education becomes all the more important in an AI-powered economy in which the rate of obsolescence of skills would be faster than ever before. As India looks to formulate a new education policy, it is imperative that the government thinks ahead and asks hard questions about the continued relevance of a sequential education system, both now and in the future. Going beyond the debate on formative education, Kaplan takes on the issue of a mismatch between the supply of and demand for skills in the job market in order to highlight how inapt the current system of apprenticeship has become. One solution Kaplan proposes in his book is particularly promising: what he calls a “job mortgage” as a new type of financial instrument through which employers, vocational schools, and colleges would have an incentive to collaborate in a new way. In this proposed job mortgage market, Kaplan attempts to use free market mechanisms to match current skills acquisition to future job opportunities. He proposes to accomplish this by compelling employers to commit to an intent to employ an individual in the future if that person commits to acquire a specific set of skills over a certain time frame. This market mechanism, in other words, would ensure that training institutions tailor their programs around specific skills that employers are willing to commit to and students are willing to develop. According to Kaplan, skills acquisition would then occur in an environment in which an individual has the assurance that these skills are valued by the market, backed by an “intent to employ” guarantee.

6. The challenges and opportunities of AI's

India will have to experiment with the kind of innovative instruments that Kaplan proposes if it is to prepare itself for the challenges from a machine intelligence-driven economy in the near future. Although this is hardly the only means by which human capital can be efficiently developed, this formalization of the economic search model is a promising, if admittedly rough, approach to the challenges AI poses to the future Indian economy.

Although this regime of programs may appear to be a projection ill-suited for the present, the challenges and opportunities of AI's advances call for urgent responses, because every one of Prime Minister Narendra Modi's flagship programs is likely to be directly affected by AI's inexorable advance. Automation in manufacturing will likely lead Make in India to fall short of its promise of job creation; the pace of obsolescence in skills will likely cause Skill India to miss its goal by a wide margin; overblown fears of so-called digital colonization in recent months may become realized if consumers' data and online behavior in a Digital India are at the mercy of AI-powered platforms and services located entirely outside India. The AI-powered global economy could wipe away India's demographic dividend if its new education policies fail to anticipate and

adequately adapt for the future. Furthermore, India could face a strategic and near permanent disadvantage in the balance of power against China, given Beijing's considerable capability and ambition in its defense-driven artificial intelligence research agenda.

In the immediate term, policymakers in India should make AI a critical component of the prime minister's flagship programs. As an example, within the Make in India program, India must create special incentives for manufacturers, such as relaxing regulations and lowering trade barriers, so they:

Create regional innovation clusters, districts, and corridors by building strong linkages around manufacturing automation and robotics between universities and start-ups in India.

Similarly, the Skill India initiative should be reworked with the twin objectives of being resilient to skills obsolescence through market-based instruments that tie together the employers, the training institutes, and the students as well as paying special attention to new skills needed to survive in an AI-led economy in the future.

Digital India must be reconfigured to establish cloud infrastructure inside India on a fast-track basis: the limited capacity as it stands today is a critical infrastructure gap and a national security risk. As a part of the Digital India initiative, New Delhi must create specific incentives for building large-scale data centers in India, ideally in partnership with the state governments. The government must identify specific regions in India that are geographically suited for building massive data centers, with an assured supply of power and other critical public infrastructure required for such facilities, and promote these as preferred destinations for investment in cloud infrastructure in India under the Digital India scheme.

The spirit of Startup India, that of creative destruction rather than protectionism, must be allowed to prevail. Recent regulatory decisions in India across cities and states bearing down on taxi aggregators Uber and Ola are regressive and counterproductive; these well-intentioned regulations must be eliminated if AI is to achieve its full potential. Unless the government and domestic industry allow the marketplace to experiment with untested business models enabled by the so-called peer economy, it is unlikely that the economy will create jobs resilient to and in an AI-driven economy. It is imperative to recognize that improving start-ups' ease of doing business is not merely a regulatory measure to incubate or liquidate a business, but also a free market initiative to allow new and efficient business models to thrive.

For the first time in the history of democratic India, the formulation of a new education policy has been undertaken with a nationwide process of consultation and crowdsourcing. The massive task of analyzing the inputs received and devising the new policy is challenged both by the volume of the inputs and the complexity of myriad issues across India. Formulating the new education policy must not, however, be based solely on inputs received that are affected by current challenges, constraints, and limitations. The National Education Policy must take a long-term view of the skills economy, evaluate the continued relevance of the current system of

sequential education, and make radical recommendations on alternative models of education that would be better suited to the economy of the future. Piloting and experimenting in such new models of education must commence in the immediate future before the rapid obsolescence of the current system begins.

The government should identify public-sector applications in India where current advances in AI could make a significant impact toward building skills and capabilities domestic applications of AI. For example, New Delhi could:

Apply AI-based techniques to recognize patterns and learn about tax evasion behavior, in an effort to mine public databases to detect tax fraud and money obtained illegally with the goal of minimizing tax evasion and maximizing tax revenue

Use AI to scan records, recognize patterns of fraud, and correlate subsidy claims with other consumer data to help detect leakages of subsidies and to learn and better target direct benefits to citizens through interventions most relevant to them.

Develop natural language-processing capabilities to automate multilingual communication and interactivity across a whole range of government services and interfaces, for example, crowdsourcing via MyGov.in, voice calls, automated helplines, and chatbots for the most routine citizen-government interactions

In each of these areas, the government should collaborate with the private sector and university research labs to leverage existing technologies effectively and to rapidly create new technologies to address specific and well-defined problems.

India must view machine intelligence as a critical element of its national security strategy. At a time when AI is being viewed as a key component of foreign policy between the United States and Japan, with similar proposals of treatment being floated in India, the Indian government must formulate a national strategy on emerging technology trends with long-term strategic consequences.[46] India must seriously evaluate the DARPA model of defense research in conjunction with private sector and university collaboration in order to create dual-purpose technologies with a scope large enough to allow for development of civilian technology applications. Specifically, the Cyber Grand Challenge model of DARPA needs to be examined for its successful incentivization of academia and the private sector.

The proposed National Intelligence Grid (NATGRID) platform, which would link citizen databases, might be a good pilot candidate for creating a machine intelligence-based platform with both national security and civilian benefits and should thus be taken up on a mission mode. Another possibility is Aadhaar, a platforms-based approach to governance founded on massive data sets, which builds on the possibility articulated in Rebooting India.[47] Authors Nandan Nilekani and Viral Shah enumerate five data-based platforms that could address a broad range of governance challenges. Expanding this list to ten public databases encompassing state and local

governments would enable a robust machine intelligence architecture capable of plugging leakages in subsidies, better targeting benefits, and expanding the tax base.

7. Conclusion

From NATGRID to Aadhaar, machine intelligence-powered platforms can become a strategic instrument of governance in India across a wide range of public services. These platforms are not without their challenges: a machine intelligence-powered approach to governance will require robust digital privacy laws and a code of ethics on limits to using AI. However, the range of AI's possibilities is so vast that the full spectrum of its opportunities is difficult to fully comprehend. While India may be late to wake up to the AI revolution, Indians of many hues—consumers, technocrats, researchers, and entrepreneurs—are already participants in this revolution with many of Indian origin driving and influencing research in the United States and elsewhere. A clarion call from the prime minister to all of them, to come together and help build an AI ecosystem in India, will go a long way for India to not merely catch up to but to take a quantum leap into the AI-driven future.

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