Advance artificial intelligence for growth
Leveraging AI and robotics for India's economic transformation

April 2018

ASSOCHAM
INDIA

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Partner and Leader
Technology Consulting
PwC India

Sudipta Ghosh
Partner and Leader
Data and Analytics
PwC India

In the recent past, India has seen a keen interest and sense of optimism regarding the impact that artificial intelligence (AI), machine learning and robotics can have on society. From making subtle inroads into our lives and work through a range of products and services, AI has now gained mainstream attention in the news and media and is considered as a foundational technology for the next phase of innovation and, consequently, India's economic boom.

In combination with technologies such as the Internet of things (IoT), virtual and augmented reality, drones and cloud platforms, AI and robotics stand to become the building blocks of the Industry 4.0 revolution in India. Private businesses, start-ups, government bodies and academic circles have been making strides in coming up with newer use cases across a diverse range of sectors—and in the process proving their mettle in translating the promise of AI to demonstrable benefits. These benefits are being reaped even in sectors that are traditionally technologically less advanced, such as agriculture and public utilities.

Our 2018 research[1] on the perceived impact of AI on business and individuals revealed positive views among business decision makers and regular participants in terms of AI's potential to contribute towards socioeconomic causes like economic growth, health and well-being, and education. In addition, the government has a favourable attitude towards the use of AI to meet these goals.

Indeed, it has stepped up its efforts to kick-start and popularise AI research and development. The AI Task Force, formed under the Ministry of Commerce and Industry, Government of India, has brought together experts from diverse fields to shape the AI roadmap for the nation and has recently released its findings and recommendations to the government.

Through this report, we have articulated some of the trends shaping AI growth in general across the globe, its landmark applications in sectors across India and steps that can be taken to enable this further.
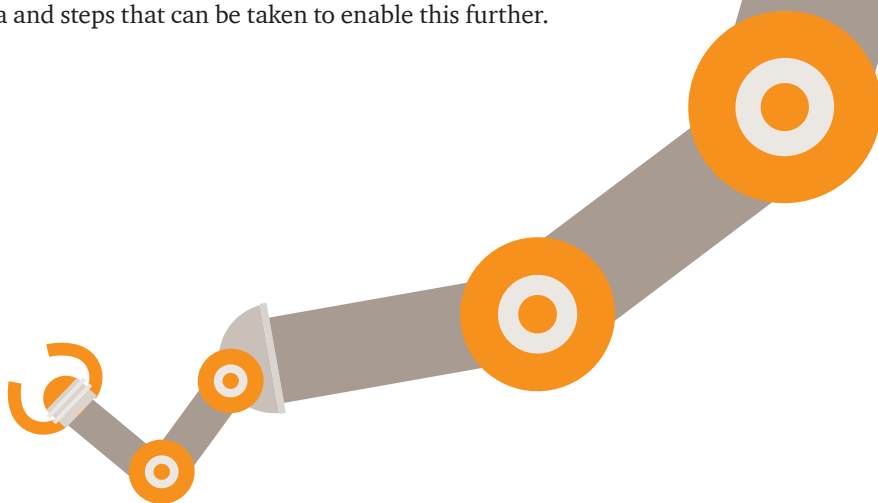
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1 PwC (2018). Artificial intelligence in India – hype or reality. Retrieved from: https://www.pwc.in/consulting/technology/data-and-analytics/ artificial-intelligence-in-india-hype-or-reality.html (last accessed on 10 April 2018)
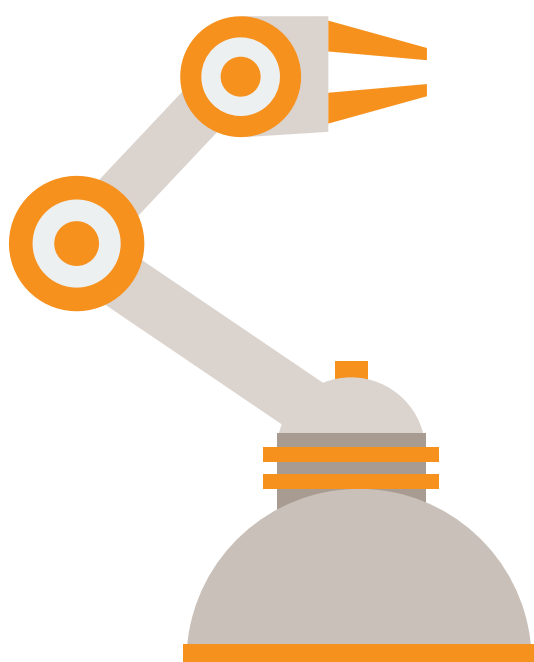
Message from ASSOCHAM

Sandeep Jajodia
President
ASSOCHAM

AI is fast becoming the most significant general purpose technology of our era. With techniques like machine learning, we can now build systems that are capable of improving their own performance by learning from data over time.

Artificial intelligence (AI) is moving from hype to reality and is increasingly cementing its importance as a building block for modern software and applications. It is finding use in a wide variety of industries or tasks within them—for example, in the form of more personalised search results on the web to daily conveniences such as app-based cab services and location-specific context-aware suggestions about restaurants, movies and other forms of entertainment.

Through this conference, we will try to examine the areas across private and public industries where the AI continuum (augmented, assisted and autonomous intelligence) could be applicable, as well as a robust AI policy framework that needs to touch upon the social and economic considerations of a well-governed society. These efforts will foster a balanced environment in India for innovation and leadership in AI.

Message from ASSOCHAM

Dr. Lovneesh Chanana
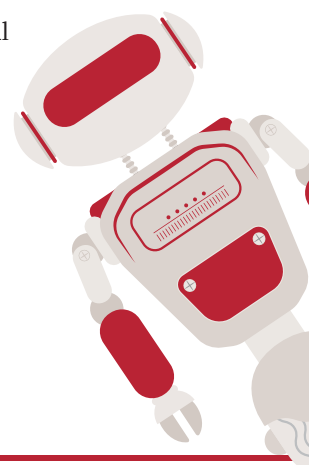Chairman, ASSOCHAM
National Council on
IT/ITES

India's journey towards embracing technology for digital transformation has come a long way. The foundation to leapfrog with the new wave of emerging technologies has been well-laid in terms of flagship programmes such as Digital India, Make in India, Smart Cities, Jan Dhan Yojana, Startup India and Skill India. Every stakeholder group can be proud of the efforts and achievements around the creation of the world's largest rural broadband network, largest direct benefit transfer system, largest digital identity system and the citizen engagement platform MyGov. These initiatives, coupled with the push to skilling and entrepreneurship, are providing the foundation for the infusion of the next wave of technology solutions around artificial intelligence (AI), the Internet of things, cyber security, blockchain, etc.

Various studies have highlighted the potential positive impact of AI on economic growth. AI will help address critical societal challenges and yield tangible benefits for citizens. It is expected to address challenges in priority areas such as healthcare, public security and disaster management. There is very clearly an opportunity for India to emerge as a leader in the development of products and services in this space. At the same time, AI offers the opportunity for businesses and governments to radically reform and redesign service delivery through intelligent systems. Globally, reference cases and applications have already emerged wherein substantive cost reduction and revenue enhancements have been projected. Indian entrepreneurs are already working and delivering products and solutions in this area.

While recognising the huge opportunity that AI holds for emerging economies like India, it is important to highlight the need to address social and ethical concerns and also the need to create an effective programme governance structure to manage the enablement of growth facilitated by intelligent systems. The programmes around AI will need to focus on skilling, reskilling and capacity building, work organisation and redesign, standardisation and interoperability, regulatory framework, cyber security and public safety. A programmatic approach can help to initiate work and move forward in this direction. Industry-government collaboration will be the key to success.

The second ASSOCHAM International Conference on 'Advance artificial intelligence for growth' will bring together all stakeholder groups to deliberate on policies, applications, solutions and requirements for the adoption of AI by Indian industry and the government. We sincerely believe that the deliberations will be beneficial for all stakeholder groups.

I wish the conference great success!

Message from ASSOCHAM

We believe that artificial intelligence (AI) has vast potential to create new industries and grow the global economy. As we strive to make meaningful progress in computer vision, natural language processing, and the physical and logical infrastructure required to run highly advanced AI systems, we remain committed to an open source model which we believe will ultimately spur more innovation, encourage collaboration and mutual review, and helps us all move faster. Academia, industry and civil society should have an ongoing dialogue about the technology as it develops to ensure that AI is used in a responsible manner.

Ashwani Rana
Co-Chairman
ASSOCHAM National
Council on IT/ITes

The global scientific community has come a long way since the development of AI as a concept to its modern-day appeal as a field with near-limitless potential in turning around the way activities are performed in a functioning society. The commercial applications of AI are massive and Indian start-ups are beginning to identify them and tap into the market, which remains at a nascent stage.

ASSOCHAM believes that the national initiatives like Make in India, Skill India and Digital India will immensely benefit from the AI technology and suggests that the government should take both long-term and short-term policy initiatives to promote AI in the country.

To understand the impact of AI on various sectors and the various policy initiatives required, ASSOCHAM has organised the 2nd International Conference on 'Advance artificial intelligence for growth'.

ASSOCHAM is committed to creating more awareness about the subject and this background paper, jointly prepared by PwC and ASSOCHAM, is a step in that direction. We congratulate the team for their efforts and convey our wishes for the success of the conference.

D. S. Rawat
Secretary General
ASSOCHAM
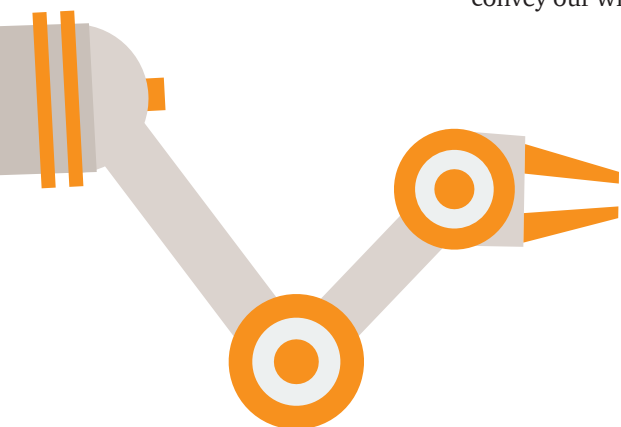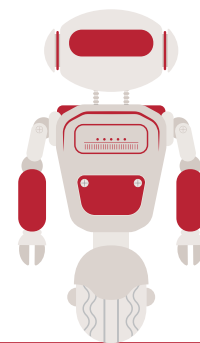
1. Introduction

Artificial intelligence (AI) is fast becoming the most significant general purpose technology of our era. With techniques like machine learning (ML), we can now build systems that are capable of improving their own performance by learning from data over time.

In our Artificial Intelligence and Robotics – 2017 report,[2] we had examined the AI growth trajectory in India using the lens of the three pillars of AI research and innovation— namely the government, private sector and academia. The report highlighted on-going initiatives undertaken across each of the three groups, their potential impact on key sectors, employment-related concerns, governance challenges and impediments to creating an ecosystem that is conducive to accelerated development, and how policy panning could be shaped while taking cues from approaches taken by other nations.

Since then, there have been numerous developments in the field of AI, ML and robotics in India—both institutionally driven as well as more subtle percolations within business processes and consumer lifestyles. One of the most notable developments in the former category has been the setting up of an Artificial Intelligence Task Force by the Ministry of Commerce and Industry, Government of India, to invigorate the use of AI towards India's economic transformation.

The Artificial Intelligence Task Force recently launched a report[3] which throws light on the state of AI in some of the most influential sectors in India—such as manufacturing, financial services, agriculture, and defence—and the dominant challenges plaguing each of these sectors. Further, it provides certain recommendations for the government to further the cause of AI-led economic development.

The 2018 Budget also indicated the government's intent towards investing in research in new areas like AI and robotics as part of a broader technology drive for the digitisation of India.[4] National Institution for Transforming India (NITI) Aayog, a think tank of the Government of India, was tasked with establishing a national programme to conduct research and development in the above and other new age technologies.

In this report, we have tried to examine the current state of AI development in India in tandem with the government's vision for a smarter 'Digital India' at the core. The emphasis is on the advances made across sectors in India, and how the start-up and SME ecosystem have contributed (and are expected to contribute in the future) towards the above goal and the role played by academic institutions.

Further, the report examines the perceptions of Indian business decision makers and regular employees regarding the impact of AI and robotics on businesses and society and the challenges that stand in the way of maximising gains.

2 PwC. (2017). Artificial Intelligence and Robotics – 2017: Leveraging artificial intelligence and robotics for sustainable growth. Retrieved from https://www.pwc.in/publications/2017/artificial-intelligence-and-robotics-2017.html (last accessed on 10 April 2018)

3 Kamakoti, V. & others (20 March 2018). Report of the Artificial Intelligence Task Force. Retrieved from: http://dipp.nic.in/whats-new/report-task-force-artificial-intelligence (last accessed on 10 April 2018)

4 Mendonca, J. (2018). Budget 2018: Government to push research efforts in artificial intelligence. Economic Times (Software). Retrieved from https://economictimes.indiatimes.com/tech/software/budget-2018-government-to-push-research-efforts-in-artificial-intelligence-says-arun-jaitley/articleshow/62738437.cms (last accessed on 10 April 2018)

2. Development and progress in AI across the globe
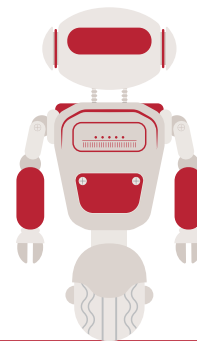
Recent advancements in hardware, platforms and applications as well as newer algorithms around the world have accelerated the commercialisation of AI and driven the race for leadership among technology giants on the one hand and nations as a whole on the other. Globally, the scope of AI applications is huge and growing. Moreover, it is increasingly getting intertwined with the overall digital transformation agenda of businesses and governments.

2.1. Recent trends and expected developments in AI

Over the past decade, as AI innovation picked up pace due to advancements in hardware and decreasing costs of computing resources, its application across sectors started gaining traction. Large technology players rapidly moved into the AI space and have redesigned existing products as well as engineered new ones so as to embed AI within them, with the aim of catering to the diverse requirements of industries.

Stabilisation of AI-powered solutions from hype to reality

AI is moving from hype to reality and is increasingly cementing its importance as a building block for modern software and applications. It is finding use in a wide variety of industries or tasks within them—for example, in the form of more personalised search results on the web to daily conveniences such as app-based cab services and location-specific, context-aware suggestions about restaurants, movies and other forms of entertainment.

While AI-focused start-ups are currently booming and investor response towards them has been warm, as ML becomes a mainstay, new technology start-ups and firms in this space would be expected to have the necessary algorithms to power their solutions. With the novelty factor wearing off, they will have to further differentiate their products from the market on other dimensions like ease of use, interoperability, robustness and support so as to build credibility and compete in the market.

Evolution of human-AI collaborative workflows

Human-robot collaborative ecosystems are on the rise, particularly in sectors such as manufacturing, logistics and healthcare. In such collaborative workflows, the heavy lifting is done by the robots (or precision operations) with human workers undertaking higher-level jobs such as programming, maintaining and coordinating robotic operations. For example, collaborative warehouse robots (or cobots) perform much of the physical work, while workers focusing on delicate tasks like guiding, monitoring and assisting robots in picking items off shelves, slotting them into separate orders and loading them to vehicles.

The advancement of narrow AI

Narrow AI (AI focused on a single task) has grown within businesses. Combined with human-AI collaborations, these narrow AI applications are reshaping businesses, sectors and markets. For example, narrow AI is being used by businesses to drive sales and customer engagement across multiple channels with the use of recommender systems, virtual private assistants, chatbots and intelligent platforms.

Further, AI is contributing towards higher operational efficiency by enhancing quality control and increasing machine uptime through predictive maintenance and prescriptive actions. As a result, companies are increasingly evolving their products and experimenting with new business models. AI tools and applications are being embedded into overall digital transformation initiatives.

Evolving dynamics of competition

Cross-border investments in AI and robotics have increased sharply in recent years. AI has already paved the path towards becoming the backbone of government-sponsored cyber security efforts. Global technology giants and AI start-ups have worked in collaboration with the government and defence bodies to bolster cyber security frameworks across the world.

These giants have already moved in on the AI market in a major way, with enterprise AI solutions integrated into their products and platforms. While on the one hand, this could provide access to AI to large as well as small users, it could also have the effect of stifling competition for AI start-ups who may now need to ally themselves with larger firms to ensure survival and sustainability.

On the other hand, larger AI players may find opportunities to extend their solutions and services to previously untouched segments with the agility, accessibility and affordability offered by their smaller, more nimble partners. Such collaborative models may also allow AI players to offer a 'full-service' stack comprising the underlying infrastructure, platform, tools and applications, on-demand expertise for customised offerings, maintenance, and training and transition management.

Increase in consumer-focused interactive and personalised AI systems

The adoption rates of smart products with AI capabilities integrated into them have shot up among B2B and B2C customers. These include voice-enabled computing and services such as digital assistants.

As the market for AI-powered consumer products further expands and smaller players join the technology giants in offering substitutes, the competitive differentiation would have to arise from greater levels of customisation and targeted functionalities. For example, in the case of voice controlled assistants, a wider gamut of language processing capabilities such as vernacular languages and colloquial vocabulary may need to be incorporated into their design.

Localisation of AI – moving towards decentralised applications

AI implementation in devices and sensors is experiencing a shift towards a decentralised learning approach. Information processing and intelligence generation are encapsulated within localised devices (such as smartphones or wearables) rather than taking place in centralised infrastructure (such as in clouds and servers). This in turn allows for faster responses (such as in autonomous cars) and greater personalisation (such as smartphone security that recognises the user's biometrics). It is also likely that hybrid models (centralised and decentralised) may find greater application in certain walks of life.

Lowered entry barriers for AI and ML platforms

Another trend in the case of AI products and offerings from technology giants and start-ups is the increasing number of open source libraries, application programming interfaces (APIs), and software development kits (SDKs).[5] As a result, the entry barriers for users and teams new to developing software using AI and ML have reduced.

An article by Gartner[6] predicts that the increased availability of AI capabilities embedded in applications and platforms will provide a boost to intelligent conversational interfaces in products and services. It states (based on a Gartner survey[7] of 3,160 CIOs across 98 countries) that **21%** of CIOs are already piloting AI initiatives or have near-term plans to do the same, while another **25%** have medium or long-term plans. The article further points out that cloud service providers integrating ML and AI into their platforms will enable organisations to rapidly ingest data and integrate robust AI capabilities into their processes.

Impact on IT spend distribution

AI's share within the IT spending budget is expected to keep increasing. An International Data Corporation (IDC) forecast estimates that the spending on AI-focused hardware, software and services will reach **58 billion USD by 2021**, up from close to 12 billion USD in 2017 and a CAGR of nearly **50%** between 2017–2021.[8] Of this, **50%** of the spending is expected to arise from software—that is, applications and platforms.

Investor interest in ML start-ups, particularly software-based ones, is increasing,[9] compared to that in their hardware- and robotics-based counterparts, owing to the speed with which they can scale. Corporate mergers and acquisitions are also on the rise.

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5 API – a set of functions or procedures that allow communication between software components
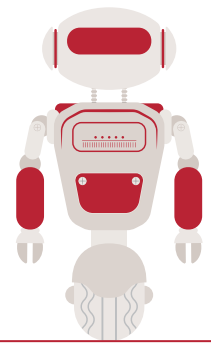
   SDK – a set of software development tools that allow programmers to develop applications

6 Goasduff, L. (19 December 2017). 2018 will mark the beginning of AI democratization. Gartner. Retrieved from https://www.gartner.com/smarterwithgartner/2018-will-mark-the-beginning-of-ai-democratization/ (last accessed on 10 April 2018)

7 Gartner. (2 October 2017). Gartner survey of more than 3,000 CIOs confirms the changing role of the Chief Information Officer. Retrieved from https://www.gartner.com/newsroom/id/3810968 (last accessed on 10 April 2018)

8 Pollard, S., Rajwanshi, V., Murphy, M. R. and others (27 November 2017). An investors' guide to artificial intelligence. JP Morgan. Retrieved from https://flamingo.ai/wp-content/uploads/2017/11/JPMorganAnInvestorsGuideToArtificialIntelligencev2.pdf (last accessed on 10 April 2018)

9 Columbus, L. (18 February 2018). Roundup of machine learning forecasts and market estimates, 2018. Forbes. Retrieved from https://www.forbes.com/sites/louiscolumbus/2018/02/18/roundup-of-machine-learning-forecasts-and-market-estimates-2018/#c2a21302225c (last accessed on 10 April 2018)

3. How AI has evolved in India in the recent past

3.1. Government push towards AI innovation and development

The Government of India has recently undertaken several initiatives to pave the way for AI-led economic transformation in India. While these initiatives have been at a strategic level—focusing on 5–10 year plans for increasing research and development as well as commercial uptake of AI-powered solutions—future initiatives are expected to take on a more operational approach with specific incentives aimed at facilitating the integration of smart solutions within sectors and functions.

In terms of providing financial support for AI programmes, the Ministry of Electronics and Information Technology, Government of India, has been funding projects by educational institutions in the areas of ubiquitous computing and wireless sensor networks for real-time landslide monitoring and perception engineering (e.g. artificial sensing, perceptual robotics). The ministry has also been operating a Technology Incubation and Development of Entrepreneurs (TIDE) scheme for facilitating technology innovation over the last decade.[10]

Further, there is potential for companies to set up AI-focused innovation centres in India with government encouragement through initiatives such as Digital India and Make in India, which have created a favourable regulatory environment. More than **36%** of large financial establishments have already invested in these technologies and around **70%** plan to embrace it in the near future.[11]

10 MeitY. (n.d.). Technology Incubation and Development of Entrepreneurs (TIDE). Retrieved from http://meity.gov.in/content/technology-incubation-and-development-entrepreneurs (last accessed on 10 April 2018)

11 Belgavi, V., Gandhi, M., Kshirsagar, H., & others. (2017). FinTech Trends Report – India 2017. PwC and Startupbootcamp. Retrieved from https://www.pwc.in/assets/pdfs/publications/2017/FinTech-india-report-2017.pdf (last accessed on 10 April 2018)

3.2. Sectoral adoption and use cases

The Artificial Intelligence Task Force, in its recommendation report to the Government of India, has identified the following areas of focus for AI-led developments:[12]

Manufacturing and supply chain

Healthcare

Agriculture

Financial services

Education

Consumer and retail

Accessibility technology for the differently abled

National security and defence

Public and utility services

Environment

In India, agriculture is the biggest contributor in the primary sector at **17–18%** of the GDP.[13] Being an agrarian country, adopting the latest technology to foster growth, is a natural choice.

Under the Make in India initiative, the government aims to increase the share of GDP from the manufacturing sector to **25%** by 2022[4]. The service sector in India, consisting of sub-sectors like finance, transportation, public administration and defence, substantially drives GDP growth. Consequently, the gains from AI are also expected to have a magnified effect on the above sectors.

With a projected annual GDP growth rate of **7–7.5%** for the Indian economy (FY 2019),[15] it would be prudent to unlock the true potential of **2.2%** of the population that is differently abled.[16] Technological developments could help this segment in overcoming barriers, improving their quality of life and contributing to their full potential towards the economy.

The following sections elaborate on the developments and real-life applications of AI which have stood out prominently within each of the above-mentioned sectors.

12 Kamakoti, V. & others. (2018). Report of the Artificial Intelligence Task Force. Department of Industrial Policy and Promotion. Retrieved from http://dipp.nic.in/whats-new/report-task-force-artificial-intelligence (last accessed on 10 April 2018)

13 Sunder, S. (29 January 2018). India economic survey 2018: Farmers gain as agriculture mechanisation speeds up, but more R&D needed. Financial Express. Retrieved from http://www.financialexpress.com/budget/india-economic-survey-2018-for-farmers-agriculture-gdp-msp/1034266/ (last accessed on 10 April 2018)

14 India Brand Equity Foundation. (March 2018). Manufacturing sector in India – Analysis and forecast. Retrieved from https://www.ibef.org/industry/manufacturing-sector-india.aspx (last accessed on 10 April 2018)

15 Financial Express Online. (29 January 2018). Economic Survey 2017-18: India GDP growth rate seen bouncing back 7-7.5% in FY19. Retrieved from http://www.financialexpress.com/budget/economic-survey-2017-18-gdp-growth-india-growth-rate-rebound-arun-jaitley/1034135/ (last accessed on 10 April 2018)

16 Kamakoti, V. & others (20 March 2018). Report of the Artificial Intelligence Task Force. Department of Industrial Policy and Promotion. Retrieved from http://dipp.nic.in/whats-new/report-task-force-artificial-intelligence (last accessed on 10 April 2018)

Manufacturing and supply chain

Industry 4.0 digitisation—IoT-enabled supply chains, advanced analytics, AI and ML techniques—have been transforming the manufacturing sector by incorporating greater visibility, flexibility and operational efficiency in the supply chain. Some of the leading use cases of advanced analytics, AI and robotics in manufacturing include:

- Robust demand forecasting based on critical demand drivers; improved decision making through structured scenario analysis

- Inventory optimisation using statistical modelling techniques to perform inventory stock level vs lost sales scenario analysis

- Predictive maintenance models using data related to machine performance and downtime history

- Optimisation of manufacturing processes by enhanced monitoring and auto-correction of processes; identification of inefficient machines and processes and adjusting parameters to improve yields

- Reduction in cost-of-poor-quality by quantifying implicit and explicit costs associated with poor quality of work in progress (WIP) and finished goods—for example, warranty payouts, cost of raw material scraps, quality inspection costs

A multinational conglomerate and manufacturer of electronic systems and equipment has applied AI-based scheduling systems to warehouse management, resulting in an 8% increase in productivity through order prioritisation and picking efficiency, a 15% boost in sales and 27% increase in order rates. The AI solution is also being applied in other areas like finance, transportation and utilities by the company across over 50 projects.[17]

A start-up firm headquartered in Singapore has disrupted logistics and supply chain processes by designing and manufacturing robotic systems for automation at warehouses, distribution centres and fulfilment centres.[18] *The start-up has introduced warehouse robots which are capable of fetching items from warehouse shelves, ranging from smartphones to FMCG goods. Another type of robot—an intelligent conveyor belt—sorts parcels by their dimensions, weight, and delivery location faster than humans (nearly four times as fast). The robots sort up to 1.2 crore parcels a month have been pitched to be a cost-effective alternative to warehouse workforce. India's largest and most prominent e-commerce firms are among the start-up's clientele. As the leading e-commerce players in India compete to draw in demanding customers with same-day deliveries, discounts and simplified returns, warehouse efficiency and lowered costs could prove to be key enablers for the growth of AI and robotics in the logistics sector.*

The successful application of AI and robotics in the manufacturing and supply chain sector has the following dependencies, where government and private sector intervention may be required:

a. Standards for data transformation and exchange for the large volumes of data generated by IoT-enabled machine-to-machine (M2M) communication

b. High-bandwidth industrial communication networks that enable machines, robots, wearables, sensors and actuators to exchange data at high speed, allowing real-time monitoring and updates

c. Faster and more streamlined workflow from ideation to approval for testing and deployment of novel technologies such as autonomous vehicles and collaborative robots

d. Provisions for vocational training to industrial workers on using smart machine tools and collaborating with robotic agents

e. Introduction of domain-focused education in schools and universities covering applications of AI, ML and robotics in an industrial product focused scenario— for example, as course materials in core engineering steams like mechanical and electrical engineering, and industrials products management

In the transportation function, data on geo location, traffic and weather can be used for smart scheduling so as to overcome jams and allow for real-time route adjustments. Further, AI and ML come into play in enabling semi-autonomous driver assistance, autonomous fleets for ride sharing, engine monitoring and predictive maintenance of vehicles. Advanced supply chains are being developed using expert decision systems. Automated vehicles and driver assistance systems enabled using computer vision can now transport goods more efficiently. These technologies reduce the vulnerabilities of a supply chain caused on account of weather, traffic or unnatural events.

A start-up firm in India has come up with an AI system in the form of a powerful camera which borrows the intelligence of machine learning to analyse driving patterns and can help determine the cause of an accident.[19]

17 Hitachi. (2017). Take on this unpredictable business age together with Hitachi AI Technology/H. Retrieved from http://social-innovation. hitachi/in/solutions/ai/pdf/ai_en_170310.pdf (last accessed on 10 April 2018)

18 Sharma, N. (7 October 2017). Now robots are coming after India's low-cost labour. Bloomberg Quint. Retrieved from https://www. bloombergquint.com/technology/2017/10/04/now-robots-are-coming-after-indias-low-cost-labour (last accessed on 10 April 2018)

19 Dalal, M. (20 May 2017). 10 standout start-ups taking an AI leap in India. Livemint. Retrieved from https://www.livemint.com/Leisure/ u7M3e5ymwmGf6QRLaXBoAJ/10-standout-startups-taking-an-AI-leap-in-India.html (last accessed on 10 April 2018)

Healthcare

The healthcare sector in India is already burdened with the high population relative to the number of physicians and care professionals. As a result, a large segment of people is deprived of even primary healthcare services.

While an absolute increase in the number of care providers may not be immediately feasible, access to AI-powered intelligent technologies can boost the productivity and accessibility of the existing resources such that they can serve more patients with the dual benefits of improved outcomes and at lower expenses.

Indian start-ups and SMEs have leveraged AI to address the demand for high-quality and affordable healthcare in the country.

Start-ups offer solutions and services aimed at capturing patient data using sensors in smartphones and wearable devices, remotely extracting information from patient records for monitoring health, supporting diagnosis, enabling health trackers and predicting onset of symptoms, and powering patient connectivity with specialists. These start-ups have been able to use big data and AI to detect conditions like cancer from medical imagery and reports and to develop customised treatment plans for individuals. Thus, AI in India is enhancing the productivity and availability of physicians.

A team of experts from a renowned technology institution in India working alongside a Kolkata based medical centre has devised an AI-assisted model for automatically grading the aggressiveness of breast cancer. The solution relies on deep learning algorithms to identify high-risk and normal tumour types. In the process, it helps overcome human error.[20]

AI-enabled robots can assist surgeons in conducting precise surgical procedures. AI platforms have already established their credibility as expert systems for advising medical practitioners on the diagnosis of diseases like cancer and recommending treatments. Other use cases for AI include early identification of potential pandemics and tracking disease incidence to contain spread, and image processing and diagnostics for radiology and pathology. Such assistive and augmentative applications of AI play a critical role in enhancing efficacy, particularly that of less experienced practitioners. In addition, they make healthcare accessible to a wider strata of the society.

The 'Da Vinci' surgical robot has been installed in around 20 cities and is operated by over 300 trained surgeons. Benefits include reduced blood loss, lower risk of wound infection, quicker recovery times and saving healthy tissue from damage.[21] *The minimally invasive surgical system circumvents the traditional surgical procedures involving large open incisions and laparoscopy or less invasive incisions. The range of procedures which can be successfully performed using the Da Vinci system span multiple departments— cardiology, gastroenterology, urology and more—and treatments such as coronary artery disease, colon and rectal cancer, and liver disease.*[22]

A Bengaluru based start-up has developed an app that allows users to take a snap of their face which it then scans for acne, spots, etc. The app also recommends a treatment regimen.[23]

Further, AI- and ML-led innovation in healthcare will be dependent on the availability of sufficiently high-quality data in electronic health and medical repositories.

The key enablers of AI growth in the healthcare sector which would require intervention from the government are:

a. Defining data sharing protocols and frameworks such as individual patient data vs aggregate derivations from public health databases and electronic health records

b. Training programmes for physicians, nurses and healthcare workers in effectively applying data science techniques and interacting with AI-powered technologies at work

c. Cross-border collaboration or partnership with giants to identify use cases and deploy auto-diagnostic techniques, medical robots and human-machine interfaces for treatment and surgery

d. Laying down of ethical guidelines related to the sharing and usage of medical data and protocols for acting on recommendations from AI-based expert systems
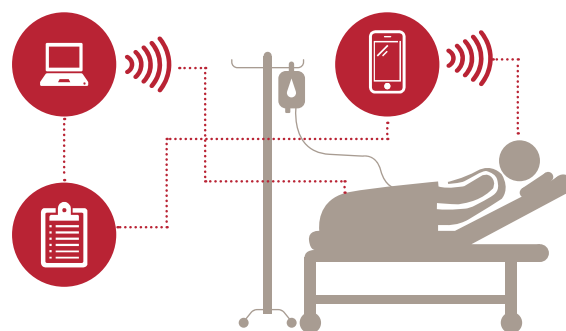
20 IANS. (23 July 2017). Indian scientists tap AI to identify aggressive breast cancer. Indian Express. Retrieved from http://www.newindianexpress.com/lifestyle/health/2017/jul/23/indian-scientists-tap-ai-to-identify-aggressive-breast-cancer-1632477--1.html (last accessed on 10 April 2018)

21 Tribune News Service. (21 November 2017). Surgical Robot visits DMCH, helps in invasive surgery. The Tribune. Retrieved from http://www.tribuneindia.com/news/ludhiana/surgical-robot-visits-dmch-helps-in-invasive-surgery/500936.html (last accessed on 10 April 2018)

22 Apollo institute of robotic surgery. (n.d.). Da Vinci Robotic System. Retrieved from https://www.apollohospitals.com/departments/robotics-surgery/da-vinci-robotic-surgery (last accessed on 10 April 2018)

23 Sharma, S. (23 November 2017). This AI-enabled dermatology app aims to save Indians the blushes. Factor Daily. Retrieved from https://factordaily.com/cureskin-ai-skincare/ (last accessed on 10 April 2018)

Agriculture

Agriculture and allied sectors like forestry and fisheries accounted for over 13% of India's GDP (2013) and over 50% of the workforce.[24]

Inadequate demand prediction, lack of assured irrigation, soil degradation, overuse/misuse of pesticides and fertilisers, availability of capital for farmers, and unorganised and low-tech practices are some of the current challenges prevalent in the sector.

Farming can greatly benefit from AI-powered intelligent solutions that enable smarter production, processing, storage, distribution and consumption of agricultural products. Site-specific and timely data about crops facilitates the application of appropriate inputs on fertilisers and chemicals, crop health and disease, spreads, monitoring health of farm animals, and intelligent farm mechanisation through autonomous machines such as harvesters, thus improving the yield per square unit of land. Further down the value chain, AI and ML systems can make commodity packaging and storage more effective with lower wastage and spoilage.

One of the largest technology firms is working with the Government of Karnataka to develop a multi-variant agro-commodity price forecasting model using AI, ML on the cloud, satellite imaging and other advanced technologies. This model can be used to determine the minimum support price (MSP) for commodities like 'tur'. With guidance from the Karnataka Agricultural Price Commission (KAPC), Department of Agriculture, the technology giant is experimenting with inputs like historical sowing area, production, and yield and weather data sets on its platform for farmers to make informed marketing decisions.[25,26]

Further, the organisation has collaborated with the International Crop Research Institute for Semi-Arid Tropics (ICRISAT) to develop an AI-based sowing app which notifies farmers of the optimal time for sowing in order to get a good harvest. Farmers in the state of Andhra Pradesh (over 170 farmers) were reported to have achieved an average 30% higher yield per hectare compared to the previous year based on inputs from the AI-based app.[27]

An Indian start-up is working on mechanising farms through a combination of a semi-autonomous vehicle with robotic arms, 3D location and vision. It has introduced a cotton picking machine aimed at achieving comparable levels of performance as human pickers while minimising manual, repetitive efforts. Human labourers coordinate the robot's actions by guiding them through rows of plants, unloading the picked cotton, etc.[28]
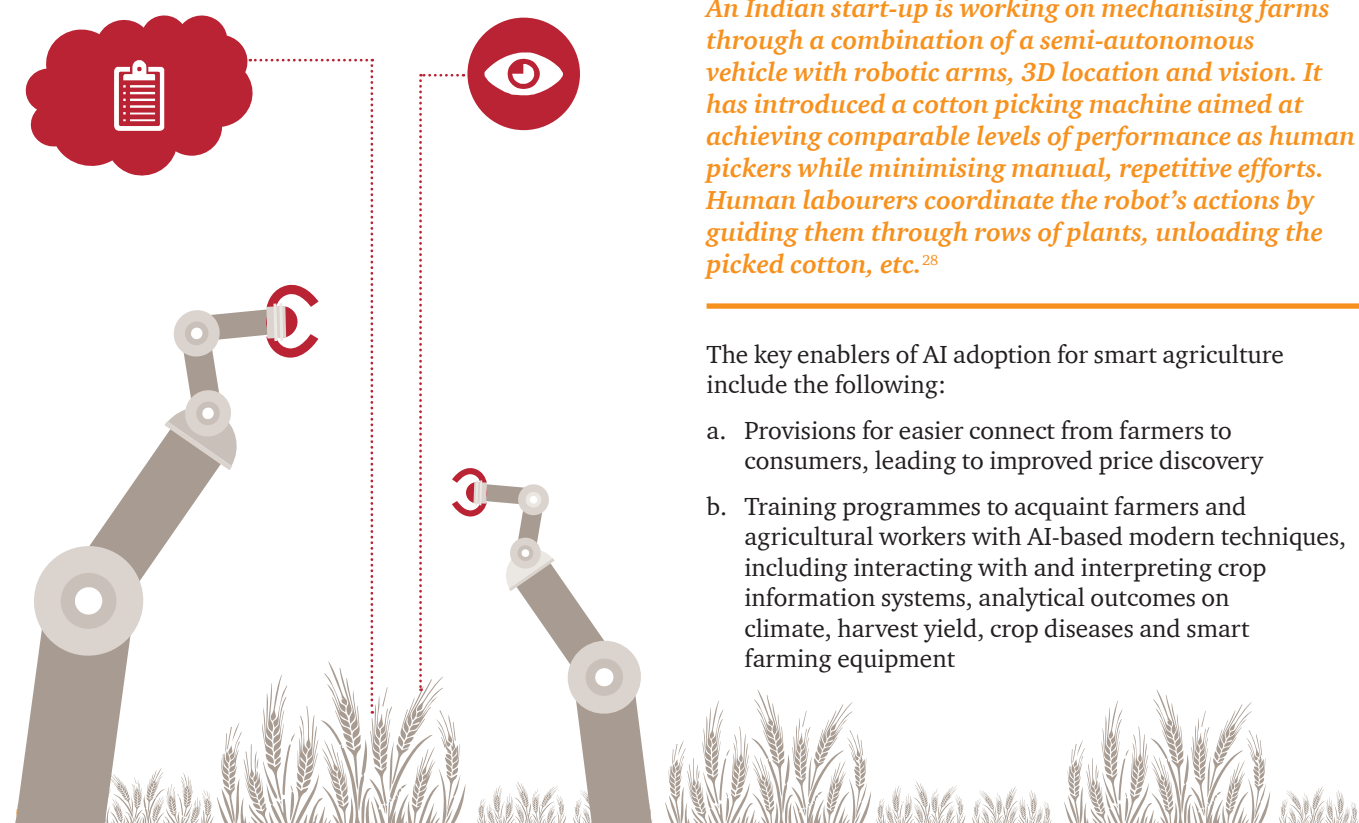
The key enablers of AI adoption for smart agriculture include the following:

a. Provisions for easier connect from farmers to consumers, leading to improved price discovery

b. Training programmes to acquaint farmers and agricultural workers with AI-based modern techniques, including interacting with and interpreting crop information systems, analytical outcomes on climate, harvest yield, crop diseases and smart farming equipment

24 Kamakoti, V. & others (20 March 2018). Report of the Artificial Intelligence Task Force. Department of Industrial Policy and Promotion. Retrieved from http://dipp.nic.in/whats-new/report-task-force-artificial-intelligence (last accessed on 10 April 2018)

25 Kulkarni, V. & Ganesh, V. (27 October 2017). Farmers look to harvest the fruits of AI. Hindu Business Line. Retrieved from https://www.thehindubusinessline.com/economy/farmers-look-to-harvest-the-fruits-of-ai/article9928335.ece (last accessed on 10 April 2018)

26 Express Web Desk. (27 October 2017). Karnataka govt. inks MoU with Microsoft to use AI for digital agriculture. The Indian Express. Retrieved from http://indianexpress.com/article/india/karnataka-govt-inks-mou-with-microsoft-to-use-artificial-intelligence-for-digital-agriculture-4909470/ (last accessed on 10 April 2018)

27 Microsoft. (n.d.). Digital agriculture: Farmers in India are using AI to increase crop yields. Retrieved from https://news.microsoft.com/en-in/features/ai-agriculture-icrisat-upl-india/ (last accessed on 10 April 2018)

28 Borpuzari, P. (1 December 2017). Robot harvester: This precision farm machine can shape the future of India's agriculture. Economic Times. Retrieved from https://economictimes.indiatimes.com/small-biz/startups/features/robot-harvester-this-precision-farm-machine-can-shape-the-future-of-indias-agriculture/articleshow/61763826.cms (last accessed on 10 April 2018)

Financial services

AI, ML and robotics have a wide range of use cases in financial services. However, their potential has not been fully realised in India. On the upside, though, financial services giants and FinTech firms have joined hands on proof-of-concept initiatives centred on the use of AI and ML to automate and streamline workflows in institutions. This includes the use of chatbots to facilitate automated conversational flows and efficient customer service, intelligent agents such as robo-advisors for personalised financial planning, and advanced algorithms to facilitate fraud detection and prevention of money laundering.

One of the world's leading trade finance banks is working with technology giants in the AI and ML space to develop cognitive solutions that combine robotics and optical character recognition (OCR) to increase the safety and efficiency of trades.[29]

Large financial bodies such as payment regulators handle billions of transactions each day across different channels such as ATM withdrawals, credit card payments, and e-commerce transactions. Advanced analytical techniques and ML algorithms, combined with human expertise allow institutions to flag transactions as potentially fraudulent at the time of occurrence and hence contain the damage as early as possible.

The advent of intelligent technologies comes at a time when the government is pushing towards financial inclusion across the Indian economy by introducing schemes like Jan Dhan and Cashless India. The importance of AI systems for drawing insights from large volumes of data and ensuring transparency, speed and efficiency and regulatory compliance cannot be overstated.

In addition, automated workflows and algorithmic risk scoring in banking and non-banking financial institutions can further reduce incidents of breaches in compliance arising from malpractices, lapses in human judgement, and low visibility on financial exposure to certain counterparties and more. This would be expressly valuable to the lending segment which has recently come under the microscope with respect to the risk assessment techniques used. Innovations in AI such as 'lean data learning' techniques could allow institutions to assess micro businesses and SMEs on limited historical data and in turn improve capital access to them.

AI, ML and robotics can potentially revolutionise customer experience, especially at the 'last mile', by providing more personalised services and improving the back-office efficiencies at financial institutions.

An Indian robot manufactured in China, 'Mitra', is able to recognise the nationalities of and guide customers in a bank. It has been deployed at the Bengaluru branch of a prominent Indian bank.[30]

Powered by customer data captured using different sensors, AI, robotic process automation (RPA) and IoT are gaining a foothold within the insurance sector in areas such as improving underwriting efficiency and automated handling of claims.

A Bengaluru-based firm specialises in providing RPA solutions (among other technologies), having provided solutions in areas within insurance like claims registration, credit note refunds, policy cancellations, no claims discount verification and policy issuance.[31]

The financial services sector is critical to economic stability and the possible implications of data privacy and security concerns are significantly high in this sector. Some of the enablers of AI adoption in the financial services sector could be:

a. Making anonymised data available from past transactions from across different financial institutions

b. Establishing data access frameworks and guidelines for open application interfaces from financial institutions

c. Provision training for employees in banking and financial services on monitoring and calibrating AI and RPA systems to ensure compliance with regulatory policies and guidelines
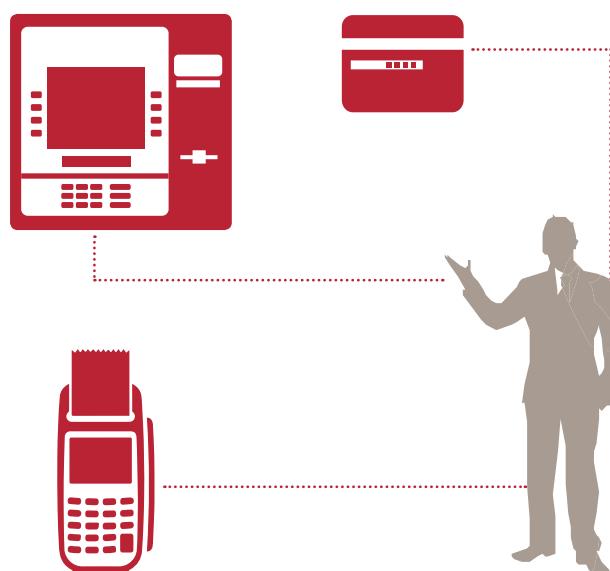
29 Economic Times CIO (10 August 2017). HSBC and IBM build cognitive intelligence solution to digitise global trade. Retrieved from https://cio.economictimes.indiatimes.com/news/business-analytics/hsbc-and-ibm-build-cognitive-intelligence-solution-to-digitise-global-trade/60004818 (last accessed on 10 April 2018)

30 PTI. (21 September 2017). Indian robot made in China steals the show at IT event. IBEF. Retrieved from https://www.ibef.org/news/indian-robot-made-in-china-steals-the-show-at-it-event (last accessed on 10 April 2018)

31 Sarkar, D. (2017). Robotic process automation in insurance industry. Nalashaa. Retrieved from http://www.nalashaa.com/robotic-process-automation-insurance-industry/ (last accessed on 10 April 2018)
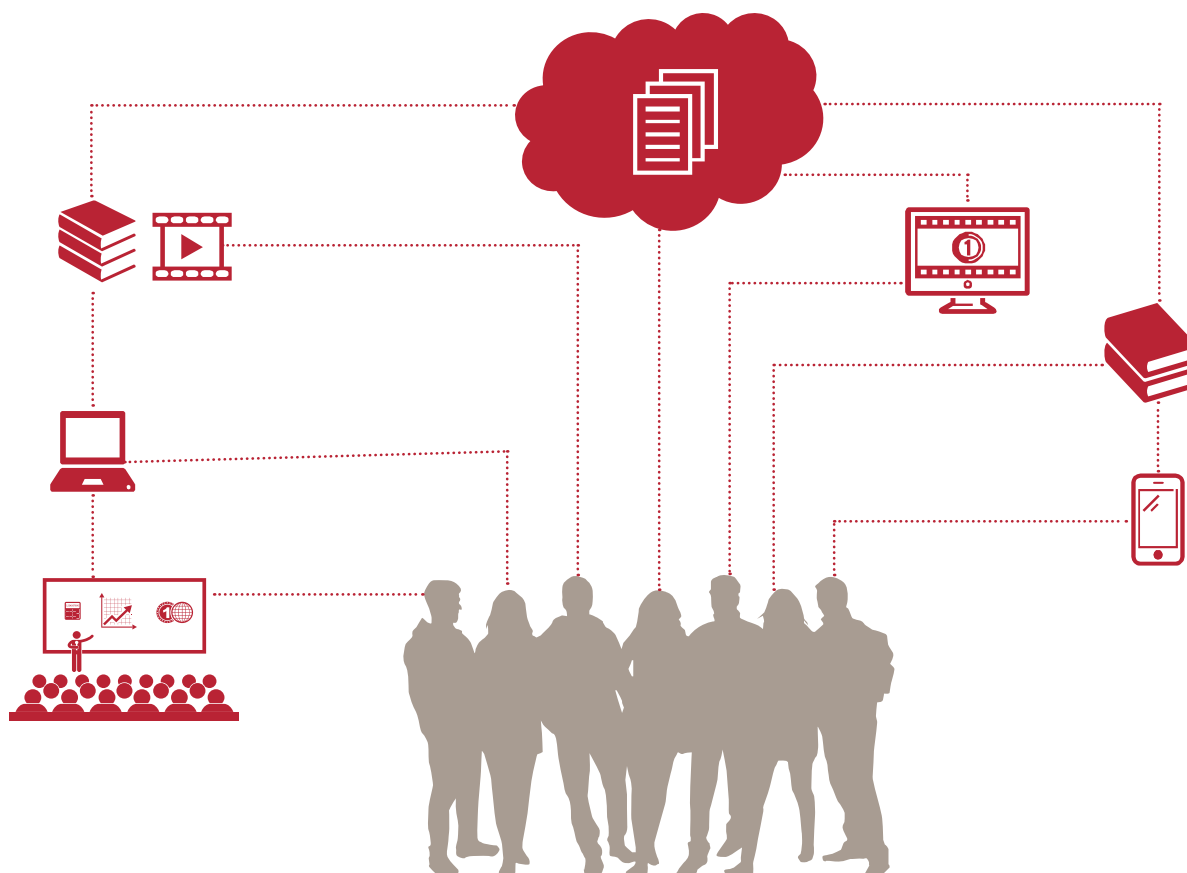
Education

Indian start-ups are successfully using AI to improve the quality of education. Data collected from students can be used to help them work on past mistakes through a process of feedback and personalised recommendations provided through an AI platform.[32] This in turn helps students improve their scores over time. To a certain extent, it also resolves the problem of teachers being unable to provide individual attention to students and of the differential pace of student learning. ML techniques are also used to provide feedback to teachers themselves. For example, by identifying areas where students lack clarity, the platform can help teachers act on their knowledge delivery and rectify the gaps.

Robotic teaching assistants connected over the cloud may alleviate the inaccessibility of experienced knowledge practitioners in remote locations by emulating their teaching style, either on a standalone basis or in real-time collaboration with human teachers.

Globally, an example of AI integration in the education sector is an AI development company that has created smart content services for secondary education that help disseminate textbook content as 'smart' study guides containing summaries and flashcards.[33]

The key enablers of AI-led transformation in the education sector are:

a. Tie-ups with universities and professional course content creators to effectively distribute open online course materials, conduct examinations through standardised evaluation templates and arrange for clearance-based certifications in the areas of AI, ML and robotics

b. An overhaul of the curriculum so as to modularise the syllabus to meet individual needs and aspirations

c. Coverage of foundational courses in data science, statistics, ML, AI, robotics, communication technology, cyber security, big data and analytics at the undergraduate and postgraduate levels

d. Pedagogical upgrades so as to include industry and public sector cases where AI techniques have been historically applied to leverage learnings about the implementation lifecycle and outcomes

e. Provision of educational opportunities that extend beyond the formative years into late adulthood—catering to a working population with the objective of making learning and re-skilling an incremental exercise over one's career

32 Dalal, M. (20 May 2017). 10 standout start-ups taking an AI leap in India. Livemint. Retrieved from https://www.livemint.com/Leisure/u7M3e5ymwmGf6QRLaXBoAJ/10-standout-startups-taking-an-AI-leap-in-India.html (last accessed on 10 April 2018)

33 Fagella, D. (1 September 2017). Examples of artificial intelligence in education. Tech Emergence. Retrieved from https://www.techemergence.com/examples-of-artificial-intelligence-in-education/ (last accessed on 10 April 2018)

Consumer and retail

AI-powered products and services such as digital assistants, customer service bots, and recommendation engines for e-commerce and entertainment portals are just a few examples of AI making inroads into the lives of consumers. AI has been deployed by Indian start-ups to improve user experience by providing personalised suggestions, preference-based browsing and image-based product search.

As per Gartner, AI bots will power 85% of customer service interactions by 2020. This may drive up to 33 trillion USD of annual economic growth.[34]

Additional uses for AI applications include personalised design and production, deep learning for predicting customer demand and orders, and efficient inventory and delivery management.

In the retail store setting, shopper-friendly robots can help assist shoppers by directing them towards the appropriate product stocked in a particular section of the store.

The operator and parent company of one of India's largest retail chains has launched a consumer and digital lab that will focus on new innovative technologies such as AI, IoT and robotics for solutions in the consumer space. The objective behind this is to enhance retail experiences in areas like payments, unique customer identification, personalised exchanges and supply chain automation.[35]

The key enablers of AI-led transformation in the consumer and retail sector are:

a. Establishment of strong frameworks for consumer data protection and product safety as well as access to quick and effective means of recourse in case of violations

b. Directing consumer engagement through human-AI interfaces such as augmented and virtual reality so that developments in these areas drive inclusion (of differently abled citizens, children and elderly groups, etc.) and provide oversight against predatory and exploitative marketing tactics

c. Promotion of greater visibility into remotely based and lesser known groups of artisans and craftsmen using intelligent interfaces to increase their reach
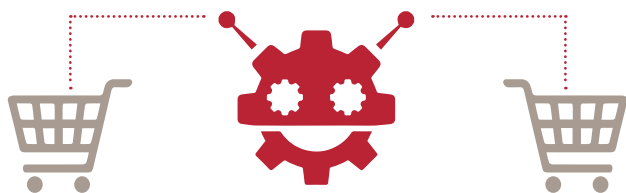
National security and defence

AI finds application in the fields of defence and security as well. It can be leveraged to protect economic sectors and infrastructure such as airports and power plants that are vulnerable to attacks. Anomalous behaviour detection in individuals and infrastructure disruption prediction (natural/man-made causes) powered by the use of distributed sensors and pattern recognition are just a few examples of the potential use cases of AI in this sector.

Along with AI applications in defence, robots can be used to perform jobs which are unsafe for humans—such as recovering explosives, detecting mines, space exploration, deep water probes, scouting for hostile territories and capturing video feed, to name a few.

The usage of AI and robots in defence and military began with unmanned aerial vehicles (UAVs) and unmanned ground systems (UGS) guided bombs and missiles. Future applications of AI and robotics in unmanned systems are likely to include:

• Target identification and classification using image processing and interpretation

• Expert systems used to diagnose weapon systems like radars and missiles

• Precision targeting systems for ammunitions leading to improved accuracy

• Trajectory analysis, impact zone and kill zone evaluation using computerised simulations

The electrically powered remotely operated vehicle (ROV) Daksh can locate, handle and dismantle hazardous objects such as explosive devices. Although it is not fully automated, developments in AI are currently under way to achieve this. In the US, the Hummingbird drone (DARPA) is a small unmanned machine used for capturing and sending video imagery.[36]

Effective application of AI for defence and national security is contingent on the following enabling criteria:

a. Inclusion of experts from a range of multidisciplinary fields such as the army, navy, air force, special forces, humanitarian studies, psychology, international law, diplomats and academicians to frame policies outlining acceptable and unacceptable practices when it comes to the use of autonomous offence and defence systems

b. Set-up of network and platform to feed information from across a range of sources—e.g., security cameras and critical infrastructure, imagery and video surveillance from aircraft, radar and satellite feeds, human intelligence, signal intelligence—into AI platforms for real-time processing of information and recognition of patterns for threat detection

34 Dhanrajani, S. (5 December 2017). Bracing for impact – AI led disruption. NASSCOM Community Blog. Retrieved from https://community. nasscom.in/community/discuss/it-services/wcit-nilf2018/blog/2017/12/05/bracing-for-impact-ai-led-disruption (last accessed on 10 April 2018)

35 PTI. (14 April 2017). Future group to set up C&D Lab in Bengaluru. Hindu Business Line. Retrieved from https://www.thehindubusinessline. com/companies/future-group-to-set-up-campd-lab-in-bengaluru/article9639675.ece (last accessed on 10 April 2018)

36 Kumar, C. (2017). Army to get self-reliant, autonomous robots soon. Economic Times (Defence). Retrieved from https://economictimes. indiatimes.com/news/defence/army-to-get-self-reliant-autonomous-robots-soon/articleshow/57466543.cms (last accessed on 10 April 2018)

Public and utility services

For public sector entities such as large energy, power and utility companies, AI and ML hold high potential in the areas of smart metering—real-time information on energy usage which reduces wastage and loss, efficient grid operation, and storage and predictive infrastructure maintenance—thus benefiting companies and consumers through cost-effective supply and usage of energy and leading to more secure supplies and fewer outages.

Customers can tailor their energy requirements through the use of smart meters and thus reduce costs. The data generated in the process could be used for customised tariffs and more efficient supply.

AI, ML and IoT form a crucial component of the government's vision of smart cities and smart industrial zones. Cities provide a wealth of information that can be captured through various sources—mass transportation tickets, cameras and sensors on roads, pavements, airports, malls, tax information, police filings, etc.—thus creating endless possibilities for improving the quality of services for citizens.

Deep learning algorithms can assimilate the volumes of data captured using IoT devices and generate actionable insights. They make it possible to figure out patterns of footfall in public spaces over a timeline, peak loads of vehicles and parking lots, and to identify increased incidence of crime at locations, among various other applications. One of the most prominent outcomes would be monitoring real-time resource usage of public facilities—power, heat, water, fuel, etc.—and autonomously adjusting inputs based on usage patterns, thus leading to significant savings.

The 2015 Draft Policy on IoT (revised), published by the Department of Electronics & Information Technology (DeitY), emphasised the government's plan of developing 100 smart cities under the Digital India programme. Some of the key aspects of smart cities highlighted were smart parking, intelligent transport systems, smart urban lighting, waste management, smart city maintenance, telecare, citizen safety, smart grid, smart energy and water management.[37]

AI can further be applied to strengthen public infrastructure such as railways, civil aviation, nuclear plants, telecommunication towers and power stations. Predictive maintenance using advanced analytical models can help improve the availability of such infrastructure and reduce safety incidents associated with them.

In order to maximise the utility of AI systems in public sector and utilities, the following enablers need to be in place:

a. Provisions for large-scale communication networks with sensors capturing information like infrastructure health, natural resource availability, chemical properties, geo-tagged data providing precise locational intelligence

b. Increased involvement of bodies like Indian Space Research Organisation (ISRO) and Indian Regional Navigation Satellite Systems (IRNSS) for setting up and calibrating geo platforms

37 DeitY, Ministry of Communication and Information Technology. (2015). Draft Policy on Internet of Things. Retrieved from https://www.mygov.in/sites/default/files/master_image/Revised-Draft-IoT-Policy-2.pdf (last accessed on 10 April 2018)

Accessibility technology for the differently abled

AI-enabled assistive technology for differently abled individuals is an as yet untapped market in India. While certain accessibility features are sometimes present in devices like smartphones, they are often secondary and not necessarily built in keeping in mind consumer centricity for the particular demographic.[38]

An example of AI-embedded accessibility features for the differently abled is the automatic captioning employed by leading video streaming sites, aimed at catering to people with full or partial hearing impairment. Similarly, AI holds high potential for easing the daily activities of people with visual, speech or mobility impairments and allowing them to operate at higher levels of productivity. For example, smartphone apps with built-in image processing capabilities can describe an object or scene or read the text of bills and documents to a visually impaired person.[39]

A global technology giant, in collaboration with an Indian eye institute, recently launched a mission-driven global consortium of like-minded commercial, research and academic institutions, who have joined hands to use AI to help eliminate preventive blindness and scale delivery of eye-care services worldwide.[40]

India is growing in terms of the quality of smart prosthetics, incorporating newer designs and technologies. However, it lags behind more developed countries when it comes to quality and advancements. Also, affordability is a barrier for those differently abled people who fall within the lower income groups. AI, in combination with other emerging technologies like 3D printing and IoT, has great potential to fuel widespread availability, affordability and feasibility of innovations in smart prosthetics.

A global technology leader has partnered with the Chinese Academy of Sciences in order to develop a prototype which translates sign language into spoken language in real time.[41]

A leading player in AI and ML is using language processing software for a tool that helps people with cognitive inpairments like autism or dementia by breaking up complex and lengthy sentences into simpler terms.[42]

Some of the key enablers for furthering AI-led innovation in products and services for the differently abled include:

a. Focused research and development in perceptual interfaces—computer-aided vision, speech and language with greater impetus to their commercialisation

b. Close coordination between technology innovations and NGOs so as to maximise reach
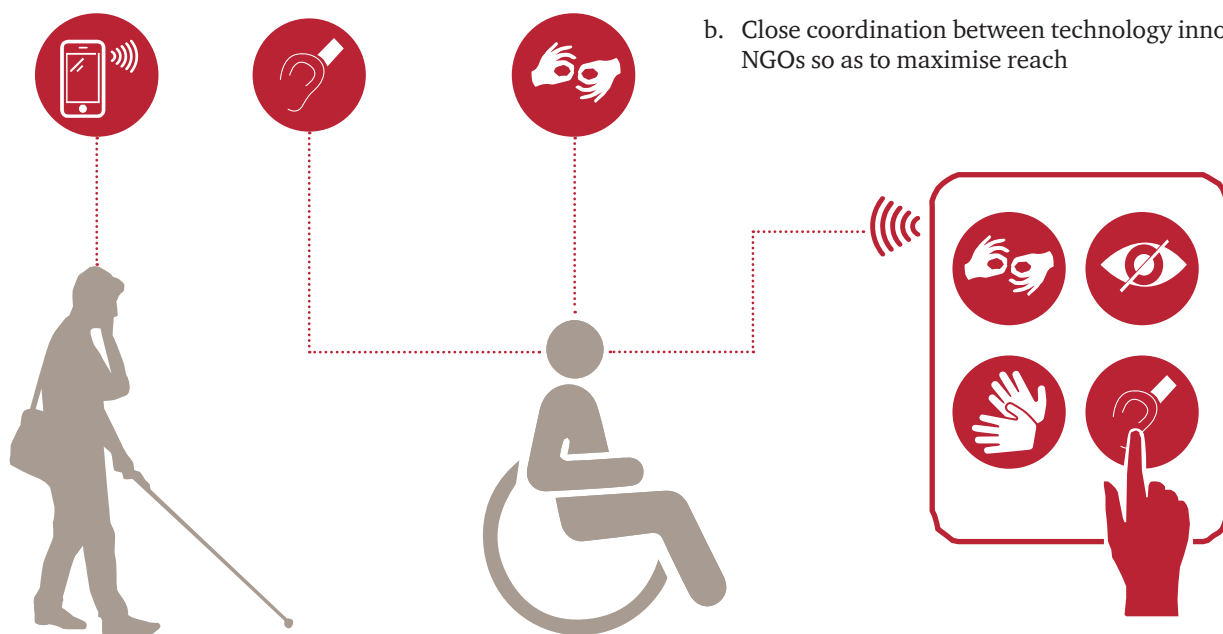
38 Umachandrani, S. (7 November 2017). How tech is making life easier for differently-abled. The Times of India. Retrieved from https://timesofindia.indiatimes.com/india/how-tech-is-making-life-easier-for-differently-abled/articleshow/61538902.cms (last accessed on 10 April 2018)

39 Ibid.

40 Mahalaskshmi, B. V. (12 June 2017). Augmenting ability: Microsoft using AI, smart glass tech to aid differently-abled. Financial Express. Retrieved from http://www.financialexpress.com/industry/technology/augmenting-ability-microsoft-using-ai-smart-glass-tech-to-aid-differently-abled/713096/ (last accessed on 10 April 2018)

41 Ibid.

42 Simonite, T. (23 March 2017). Machine learning opens up new ways to help people with disabilities. MIT Technology Review. Retrieved from https://www.technologyreview.com/s/603899/machine-learning-opens-up-new-ways-to-help-disabled-people/ (last accessed on 10 April 2018)

Environment

AI has been successfully applied in the environmental sciences globally towards the following objectives. While AI technologies for environmental sciences have not picked up significantly in India yet, globally, they have been making waves. Some of the leading areas where AI has been applied towards environmental causes are:

AI optimised 'smart' energy grids for power generation

- AI optimised energy system modelling and forecasting decreases unpredictability and increases efficiency, power balancing, use, and storage of renewable energy through intelligent grids

- Neural networks for solar: Can improve the reliability and affordability of photovoltaic energy

- Smart lighting and heating systems: To utilise lighting and heating only when required

A large global technology and AI leader launched 'Project Sunroof', an online tool based on Google Earth's 3D imagery that helps individual homeowners explore whether they should go solar by providing them with a viability report. This is done by analysing everything from high-resolution aerial mapping and 3D modelling of residential roofs based on sun position, weather patterns, shadows cast by objects, typical electricity consumption, etc.[43]

Precision manufacturing for reduced waste and emissions

- Reducing energy consumption and release of harmful gases and waste

- Precision strength: Robots minimising the need for larger less efficient machines

- Eliminating product waste: More efficient use of raw materials

- Industrial lifecycle tracking: Optimising maintenance, energy efficiency, recycling of machinery

Smart homes and smart cities

- Smart sensors in offices and homes can increase safety by indicating and possibly taking remedial action against catastrophic risks such as fire, floods and earthquakes.

- Sustainable building design can maximise energy and product efficiency in building design and improve energy efficiency by switching heating and air-conditioning on or off at the right times to exploit off peak rates.

- Energy monitors which can learn electrical signatures in a smart office or home to generate insights and alerts on energy usage.

Smart transportation systems

- Autonomous vehicles can improve the energy efficiency of road transport by identifying most energy-efficient routes and speeds.

- Big data, IoT and cloud-enabled vehicles communicate with transport infrastructure, which helps in managing vehicle flows, eco-driving and effective traffic control.

- AI-enabled autonomous drones and sensors linked to IoT platforms can offer real-time traffic and logistics information for optimised routing.

Researchers in Beijing, China have tested an AI system that can predict the severity of pollution levels in different areas. It is eventually expected to become capable of providing recommendations for controlling pollution levels, such as relocating factories and traffic density restrictions. The 'adaptive machine learning' approach is deemed to generate results that are around 30% more accurate than those of conventional approaches.[44]

Monitoring of land usage and soil erosion

- AI-enabled automated land-use change monitoring will aid in detecting and monitoring deforestation. Transparency of real-time land use practices can be enabled by drones, advanced satellites, IoT sensors and the cloud, which will be a game changer for implementing smart land use practices and driving accountability in agriculture and forestry value chains.

Disaster management and recovery

- Software applications of ML can detect patterns leading to a natural disaster (e.g. rotation tracks of cyclones, tornadoes).

- Machine leaning models can estimate the range and severity of impact and trigger automated alerts and warnings with lead time for evacuation and risk control mitigation measures.

- Autonomous robots and vehicles can find utility in highly hazardous and contaminated ecosystems in recovery and clean-up, such as a nuclear reactor meltdown.

- In the event of a flood or earthquake, robots can be used to navigate tortuous locations, including small spaces, underwater areas and debris-ridden sites.

43 Google, (December 2016). Google Environmental Report. Retrieved from https://static.googleusercontent.com/media/www.google.com/en//green/pdf/google-2016-environmental-report.pdf#page=62 (last accessed on 10 April 2018)

44 Knight, W. (31 August 2015). How artificial intelligence can fight air pollution in China. MIT Technology Review. Retrieved from https://www.technologyreview.com/s/540806/how-artificial-intelligence-can-fight-air-pollution-in-china/ (last accessed on 10 April 2018)

Disease prevention and outbreak control

- ML models have been used to predict location and severity of disease outbreaks and whether an outbreak should receive immediate attention.

- Researchers had used satellite data to trace the relationship between temperatures in the equatorial part of the Indian Ocean, leading to conditions suitable for an increase in mosquitoes and the outbreak of malaria in Africa.

Conservation of ecological habitats

Software developed with help from the Wildlife Conservation Society (WCS) is used to calculate tiger populations and investigate poaching activities in an area by matching their stripe patterns captured on camera, similar to the fingerprinting process.[45]

Using AI for environmental protection and conservation will depend on the successful set-up of the following enablers:

a. Capturing data on pollution levels generated by airborne particulates, water and solid waste and effluents using a network of sensors and communication devices

b. Defined thresholds and standards for measuring the efficacy of AI systems in controlling pollution levels
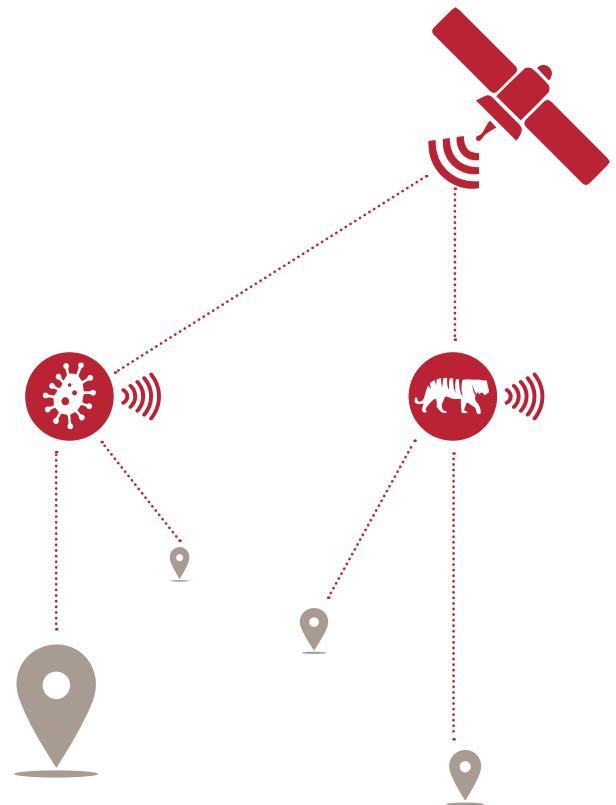
45 Science Daily. (18 March 2009). Tracking tigers in 3-D. Wildlife Conservation Society. Retrieved from https://www.sciencedaily.com/releases/2009/03/090312134639.htm (last accessed on 10 April 2018)

3.3. Growth of the start-up ecosystem

India has seen several start-ups mushroom in the AI, ML, big data and cloud space[46] which are attracting the interest of investors, a significant number of whom offer products and services in healthcare, FinTech, customer services and education. This is further propelled by the government's flagship initiatives of Make in India and Startup India. Smaller and nimbler start-up organisations are now becoming potent challengers to the existing market leaders through innovation and the adoption of newer technologies.

This shows great potential for AI/ML growth in India. Large IT services companies are already coming up with their AI platforms, while smaller niche AI start-ups are tracking specific problems, thus creating a holistic ecosystem for AI to thrive in India. AI start-ups in India are venturing into multiple industries, such as e-commerce, healthcare, education, and financial services, and retail and logistics.

Start-ups specialising in AI, ML and robotics have contributed significantly to innovation in these fields over the last few years. Digital technologies have created opportunities and allowed them to set up new revenue streams around these new technologies. These start-ups and small and medium-sized enterprises (SMEs) can become suppliers of comprehensive solutions which are either stand-alone or integrated applications which can be adopted by businesses and consumers. Other than generating new revenue streams, they can take advantage of new technologies to produce quality products at cheaper costs.

A US-based computer software company acquired a small Hyderabad-based company that specialises in helping e-commerce players store, process, and visualise data, and use that data to improve conversion rates.[47]

3.4. Academic research and inroads into AI

AI research has gained significant traction in some of the premier technology-focused educational institutions, including the Indian Institutes of Technology (IITs) and the Indian Institute of Science (IISc). In recent years, many AI-focused start-ups have been either incubated by their founders during their academic years or by alumni from the aforementioned technical institutes. For instance, students of a prominent technical institute in the southern part of India have come up with a patented technology that uses AI to predict and diagnose medical conditions like diabetes, cancer and neurological disorders.[48]

Elsewhere, alumni teams of a prestigious engineering institution have built an AI-powered tool for social media marketers which can help businesses create trending content, automate social media posts and identification of leads, thereby creating opportunities to expand their brand with a minimal promotional cost.[49]

One of the prominent IITs in eastern India is setting up an AI research Centre of Excellence that covers education, training, research, projects and entrepreneurship opportunities. The centre is expected to be seed funded for around 5.6 crore INR for infrastructure, software, simulation platforms and courseware design.[50]

However, much remains to be done in order to bring up the level of breakthrough research and outcomes from the Indian academic institutions, especially when compared to their global counterparts. According to an article in Analytics India Magazine, nearly **70%** of AI research in India is taking place at the headquarters of non-Indian companies. Within academia, the engineering talent is still largely focused on IT as opposed to research and innovation—only around **15 universities** in India contribute **42%** of all research publications arising from universities and colleges.[51]

46 Kamakoti, V. & others (20 March 2018). Report of the Artificial Intelligence Task Force. Department of Industrial Policy and Promotion. Retrieved from http://dipp.nic.in/whats-new/report-task-force-artificial-intelligence (last accessed on 10 April 2018)

47 Singh, S. (24 November 2016). India-based AI startups draw attention of tech biggies like Apple, Facebook. Economic Times. Retrieved from https://economictimes.indiatimes.com/small-biz/startups/india-based-ai-startups-draw-attention-of-tech-biggies-like-apple-facebook/articleshow/55589444.cms (last accessed on 10 April 2018)

48 Nair, D. (2017). 21-year-old IIT Madras student-entrepreneur's patented AI tech helps doctors predict future. YourStory. Retrieved from https://yourstory.com/2018/03/iit-madras-entrepreneur-ai-tech-orbuculum/ (last accessed on 10 April 2018)

49 Krishna, V. (24 March 2018). IIT alumnus builds AI-powered tool for social media marketers. YourStory. Retrieved from https://yourstory.com/2018/03/iit-alumnus-builds-ai-powered-tool-social-media-marketers/ (last accessed on 10 April 2018)

50 Mahalakshmi. (8 March 2018). IIT Kharagpur to boost artificial intelligence research. Financial Express. Retrieved from http://www.financialexpress.com/industry/technology/iit-kharagpur-to-boost-artificial-intelligence-research/1090892/ (last accessed on 10 April 2018)

51 Sinha, S. (March 2018). Where artificial intelligence research in India is heading. Analytics India Magazine. Retrieved from https://analyticsindiamag.com/where-artificial-intelligence-research-in-india-is-heading/ (last accessed on 10 April 2018)
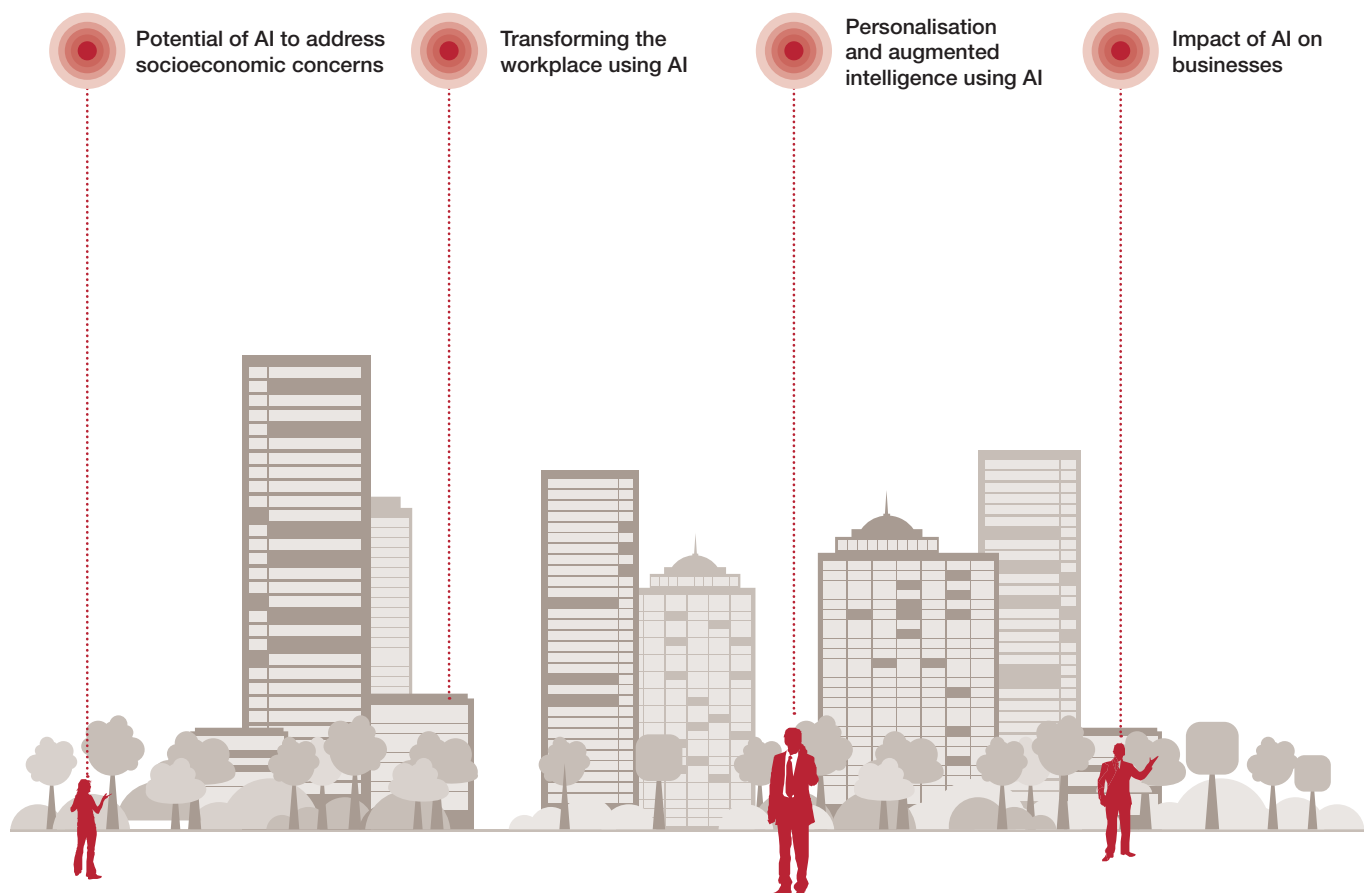
4. Perceived impact of AI on business and society
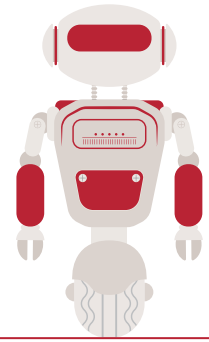
A survey conducted by PwC in 2018[52] on the perceived impact of AI among Indian business decision makers and regular employees revealed widespread optimism about AI and its potential to address socioeconomic concerns and improve productivity for businesses.

We sampled business decision makers and regular employees engaged in Indian firms via a nationwide online survey to explore:

- Attitudes towards artificial intelligence
- Its current and future implications on society
- Which areas within businesses and our lives are most likely to be impacted by AI

Potential of AI to address socioeconomic concerns

Transforming the workplace using AI

Personalisation and augmented intelligence using AI

Impact of AI on businesses

52 PwC. (2018). Artificial intelligence in India – hype or reality. Retrieved from https://www.pwc.in/consulting/technology/data-and-analytics/artificial-intelligence-in-india-hype-or-reality.html (last accessed on 10 April 2018)
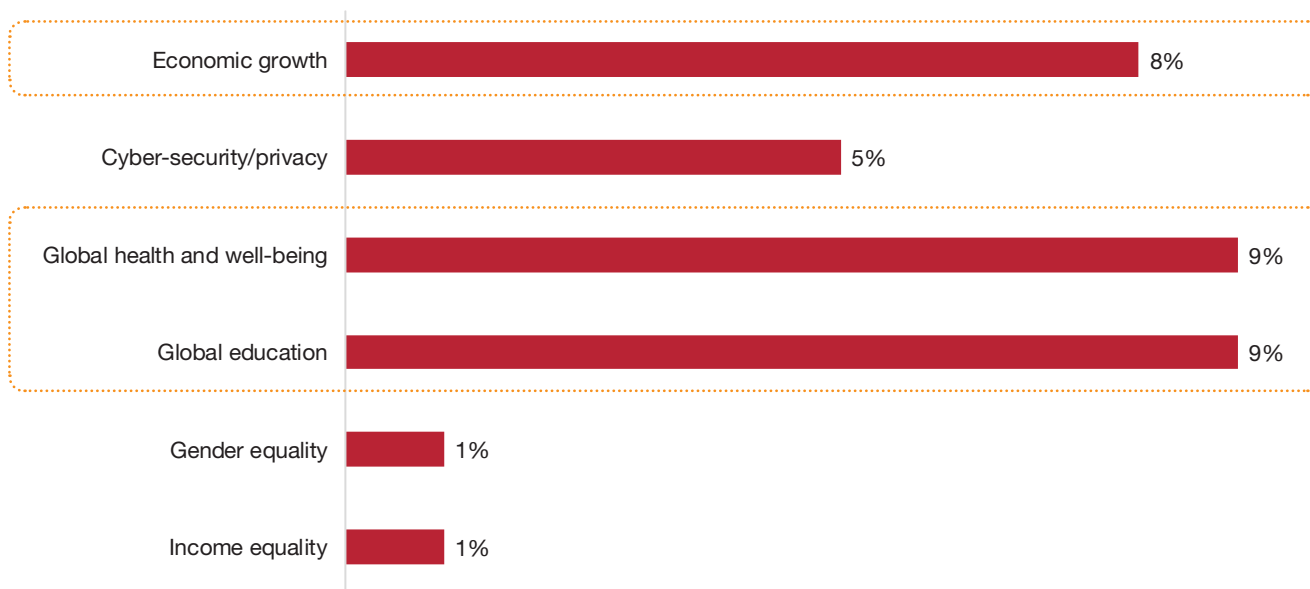
Some of the key findings of the survey are discussed below.

4.1. Impact on society and individuals

The survey sought to understand existing perceptions of the impact of AI and robotics on broad social and economic causes as well as AI-enabled service delivery. The results showed an overwhelmingly optimistic view on the impact of AI, with over **71%** of the participants believing that AI will help humans solve complex problems and live more enriched lives.

- **58–74%** of the participants indicated a positive outlook on the likelihood that AI will aid socioeconomic causes like economic growth, health and well-being, education, cyber security and privacy, and that the government would take steps towards their application for the same.

Gap between the percentage of participants who think AI is important for a cause and that businesses and the government will apply AI for the same

Cause	Gap
Economic growth	8%
Cyber-security/privacy	5%
Global health and well-being	9%
Global education	9%
Gender equality	1%
Income equality	1%

Source: PwC report on 'AI in India – hype or reality?'

- However, for causes like health and well-being, education and economic growth, participants perceived a gap (of **8–9%**) in the likelihood of AI supporting them and government implementation. This could be indicative of the need to channel AI innovation and application in these areas. For instance, around **67%** of participants felt that AI should be applied towards offering educational aid to disadvantaged children, while **64%** thought that it should be leveraged to provide affordable services to low-income adults.

- In terms of personalisation and interaction with humans, AI solutions are seen in a positive light by the Indian populace: **61%** of participants indicated having used digital assistants with perceived benefits that range from saving time, managing calendar events and reminders, and helping get things done. Further, **72%** of Indian business decision makers feel that AI can provide better one-to-one personalisation compared to humans.

- In terms of AI-rendered services, nearly half (**49%**) of the participants indicated that they would be willing to pay extra for 'smarter and higher touch customer service' run by AI, preferably with access to human agents when required.
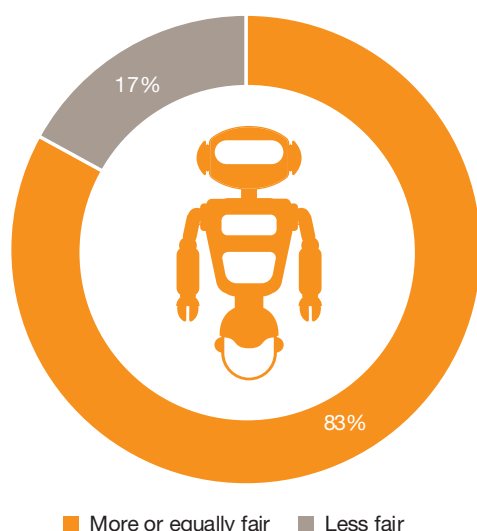
4.2. Impact on businesses and the workplace

Business decision makers from across sectors and functions who were surveyed indicated the growing importance of AI-powered solutions for their businesses.

- Close to **55%** of business decision makers believed that the benefits of AI for business through generating growth and boosting productivity will outweigh potential employment concerns.

- Business decision makers perceive specific AI-powered solutions to be most impactful in their sector or function. The most commonly cited ones include ML, virtual private assistants, decision support systems and automated research, and information aggregation solutions.

How AI advisors are perceived in terms of fairness in giving promotions and raises

17%

83%

■ More or equally fair   ■ Less fair

If you were up for a promotion against another employee, who would you want to make the decision?

25%

75%

■ AI advisor only or a combination of a human and an AI advisor   ■ Human manager

Source: PwC report on 'AI in India – hype or reality?'
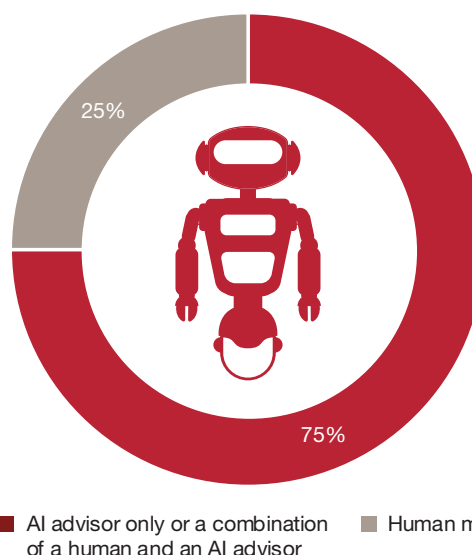
- The research also yielded the insight that AI advisors and managers may play a more crucial role in the workplace of the future. Indeed, **83%** of the business decision makers believe that an 'AI advisor' at work would be either more or at least equally rational and impartial in monitoring performance and giving promotions and raises as compared to humans. Further, **75%** of them felt that they would be comfortable with AI advisors (alone or potentially in collaboration with human advisors) taking decisions regarding their promotion.

- The perceived positive impact of having AI systems integrated at the workplace was evident from the fact that over **75%** of business decision makers were convinced that AI managers would create newer, more collaborative opportunities for work; allow for a balanced workload; free up people from menial and repetitive tasks; and provide more freedom and flexibility at work.
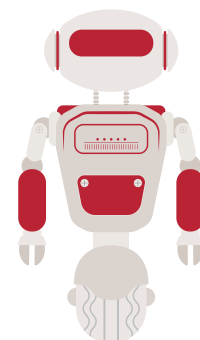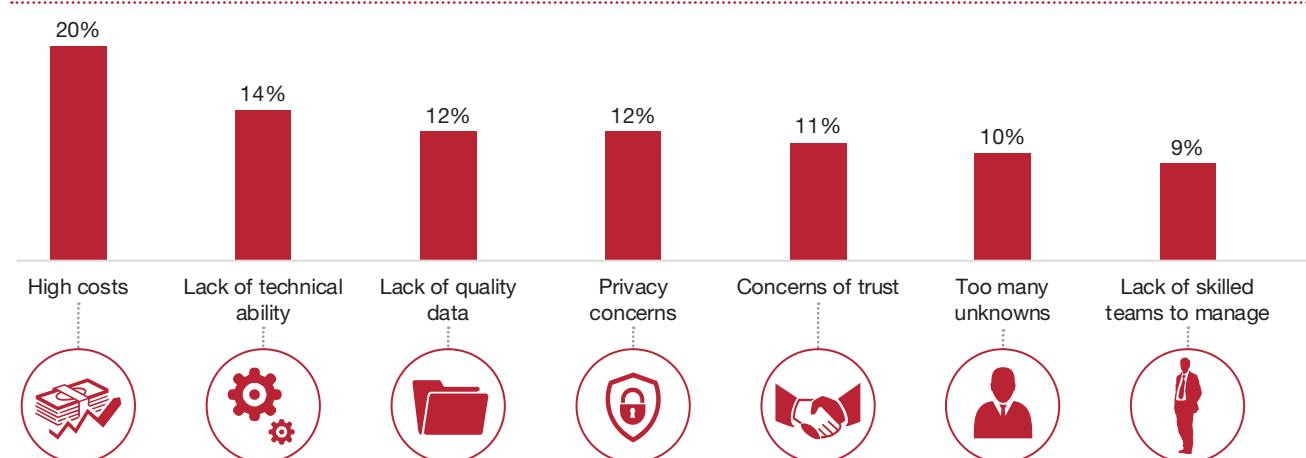
5. Tackling the challenges of AI innovation and integration

5.1. Integrating AI into industries

A 2018 study by PwC on the impact of AI on Indian businesses[53] found that high costs and the 'lack of technical ability and quality data rank among the key concerns of business decision makers when integrating AI into the workplace.

Key barriers to AI integration for businesses

20%	14%	12%	12%	11%	10%	9%
High costs	Lack of technical ability	Lack of quality data	Privacy concerns	Concerns of trust	Too many unknowns	Lack of skilled teams to manage

Source: PwC report on 'AI in India – hype or reality?'

Even though the current concern for AI is cost, this may not remain very relevant as AI becomes more affordable and ubiquitous. Once we reach that stage, data privacy and loss of human touch and expertise would stand out as the biggest barriers for AI adoption among consumers. This future challenge needs to be addressed by businesses and the government.

As per PwC's 20th CEO survey, 87% of top CEOs/ management have concerns regarding the availability of key skills related to AI.[54]

A comprehensive understanding of the current operational pain points within firms and the industry, at large, should serve as a starting point for business leaders to effectively anticipate the magnitude and urgency of change approaching them. This is rather important considering that a large number of the survey participants have indicated costs to be an inhibiting factor in AI integration in businesses. It is, therefore, imperative that executives choose their programmes based on feasibility and returns.

AI integration and cognitive transformation require time and investment. In this regard, organisations would do well if they prioritise and single-out key process and decision flows that:

a. could be automated with relative ease and with ready availability of the primary asset—that is, data;

b. could contribute towards concrete and immediate returns along the lines of improved efficiency, cost savings and customer reach.

Shared AI insight, governance and collaboration, facilitated by a team of champions, would prove to be crucial towards preventing confusion and silos of programmes. While the enabling hardware and platform ecosystems for AI and ML solutions are being commoditised, the technical skill capital required for effectively capturing and analysing data is slowly turning out to be prime assets for companies. Data science professionals, statisticians, robotics engineers and domain experts are highly sought after today. Leaders will need to undertake initiatives to build or acquire and sustain people with such skills as AI gathers pace to cover the perceived lack of technical ability to manage such transformative projects.

53 PwC. (2018). Artificial intelligence in India – hype or reality. Retrieved from https://www.pwc.in/consulting/technology/data-and-analytics/artificial-intelligence-in-india-hype-or-reality.html (last accessed on 10 April 2018)

54 PwC. (2017). The talent challenge: Harnessing the power of human skills in the machine age. Retrieved from https://www.pwc.com/gx/en/ceo-survey/2017/deep-dives/ceo-survey-global-talent.pdf (last accessed on 10 April 2018)

5.2. Safeguarding data privacy and security

With the increasing volume of data and intensity of cyberattacks, the threat of information theft and damage is exceedingly high, to the point that organisations cannot purely rely on manpower to spot such threats and come up with technologies to prevent or contain them.

A 2018 PwC AI impact research survey[55] found that concerns regarding data privacy are nearly unanimous (**93%** of the participants) to the point that people are reluctant to share, for example, their medical data even if it could provide more personalised knowledge about their health. The concerns were, however, less severe when it came to less intrusive data like transportation patterns, where participants were more willing to share such information (**57%** of participants) if it helped them get out of traffic quickly.

AI-enabled cyber security systems rely on historical data of cyberattacks and apply ML to predict and detect similar threats likely to arise in the future. Having automated systems in place for monitoring and detecting risks helps to free up human agents from the time-consuming tasks of having to continually check and categorise these red flags based on their threat level. Intelligent automation triggers these red flags based on volumes of data which humans may not have the time or cognitive resources to search through. If more sophisticated deep learning systems are developed, organisations may have a lead over the dynamic actions of cybercriminals.

The counterargument to AI for cyber security is that cybercriminals may also tap into such technologies to automate various forms of attack, leading to a potential situation with AI applications trying to hack other AI systems. In these cases, human intervention may be necessary to correctly segregate 'true positives' from 'false positive' threats.

MeitY is working closely with the Ministry of Human Resource Development (MHRD) to introduce cyber security into school curriculums to educate students about cyber threats.[56]

It becomes imperative in such a scenario to have a strong policy outlining how and when companies can capture, process and share individual data with third parties. In a healthcare setting, for example, governing policies could lead to privacy breaches caused by patient conditions being collected and shared by hospitals with other companies or agents without a patient's consent.

For AI and robotic applications and platforms, especially those that function autonomously, such as self-driving cars and predictive profiling, establishing robust legal and ethical boundaries outlined through policymaking could direct developers and leaders of AI firms so that their products are responsible, transparent and meet the checklist of acceptable conditions before they are launched in the market.

55 PwC. (2018). Artificial intelligence in India – hype or reality. Retrieved from https://www.pwc.in/consulting/technology/data-and-analytics/artificial-intelligence-in-india-hype-or-reality.html (last accessed on 10 April 2018)

56 Capital market. (12 March 2018). Centre working on introducing cyber security in CBSE school curriculum. Business Standard. Retrieved from http://www.business-standard.com/article/news-cm/centre-working-on-introducing-cyber-security-in-cbse-school-curriculum-meity-official-118031200103_1.html (last accessed on 10 April 2018)
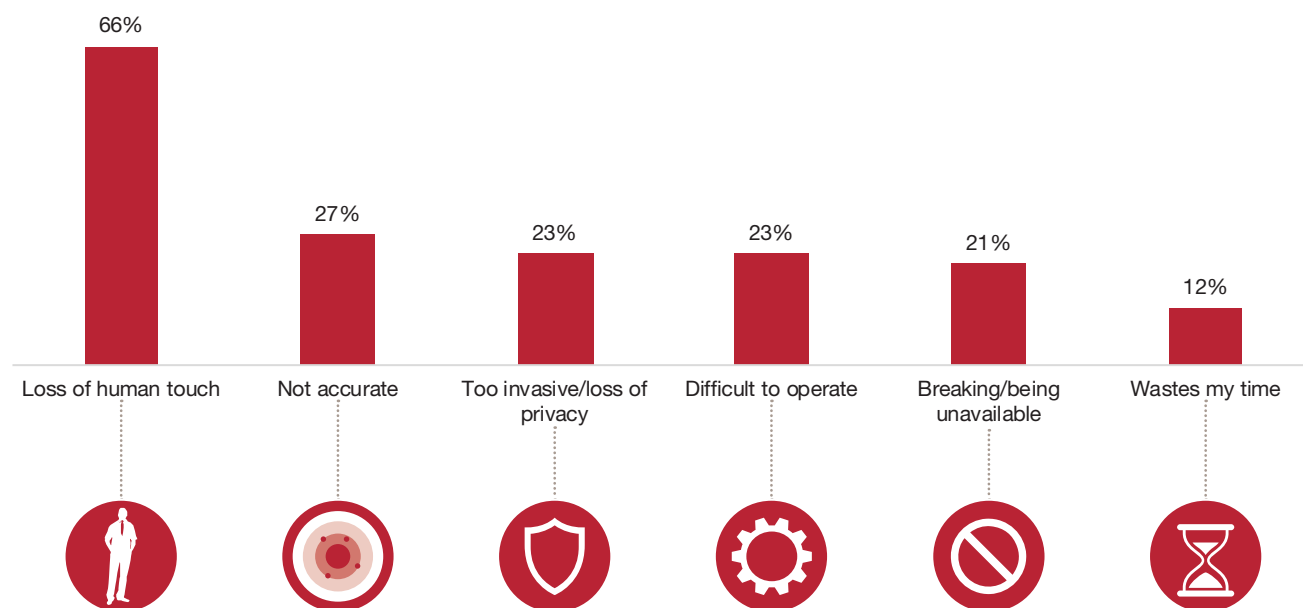
5.3. Assimilating human-AI interaction models

Based on a 2018 study by PwC on the impact of AI, some of the key concerns related to AI-run customer services, as indicated by the participants, include loss of human touch (**66%** of the participants), responses that do not adequately address user concerns, data privacy concerns and operational difficulty.
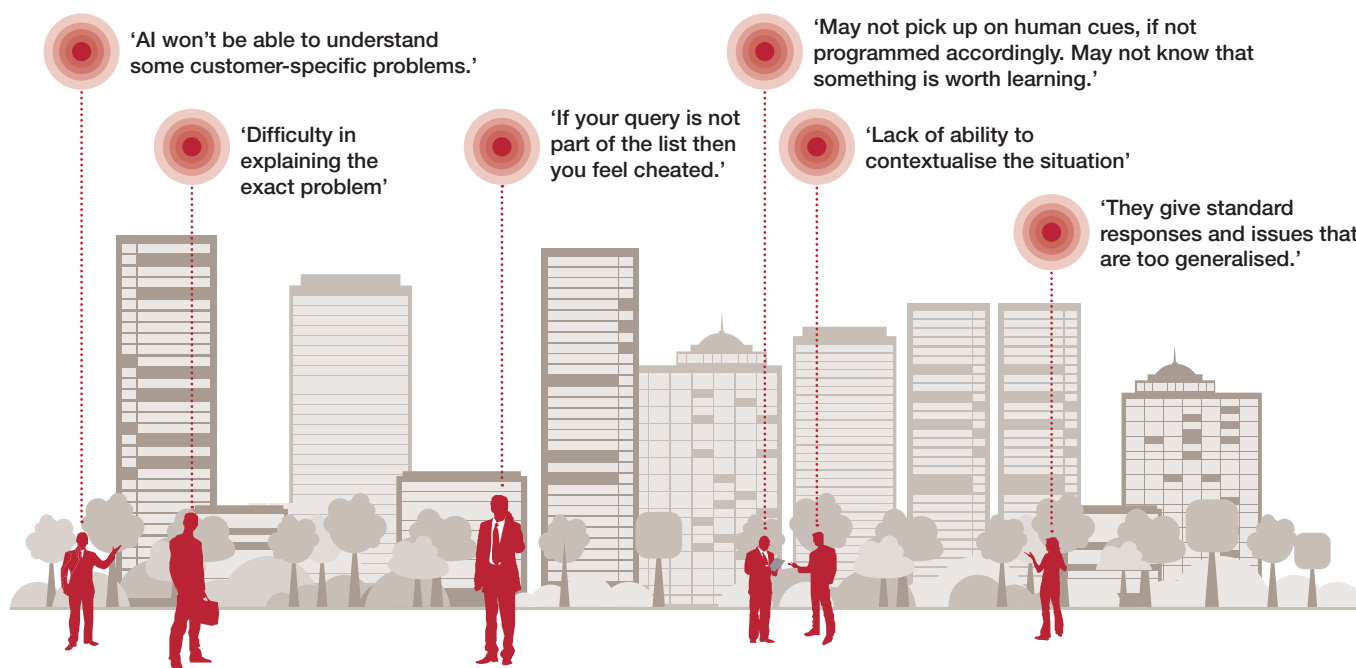
Further, participants highlighted the commonly faced challenges associated with AI-run customer service, which included:

- Being unable to grasp customer-specific problems
- Difficulty in explaining the exact problem
- Inability to pick up human cues, which in turn hampers the AI system's learning ability
- Inability to contextualise a situation
- Dependence on generic standard responses as a panacea to more nuanced problems

Key concerns associated with AI-run customer service

Loss of human touch	Not accurate	Too invasive/loss of privacy	Difficult to operate	Breaking/being unavailable	Wastes my time
66%	27%	23%	23%	21%	12%

Source: PwC report on 'AI in India – hype or reality?'

'AI won't be able to understand some customer-specific problems.'

'Difficulty in explaining the exact problem'

'If your query is not part of the list then you feel cheated.'

'May not pick up on human cues, if not programmed accordingly. May not know that something is worth learning.'

'Lack of ability to contextualise the situation'

'They give standard responses and issues that are too generalised.'

Source: PwC report on 'AI in India – hype or reality?'

In the present scenario, an AI-powered customer service set-up may also require the safety net of 'human touch' so that customers do not feel neglected or cheated and organisations are not perceived as negligent or uncaring towards their customers. This will help create a differentiated, convenient and seamless experience and greater engagement, and provide them with an 'adjustment' period as customer service interfaces inevitably become more automated over time.

5.4. Ensuring that AI systems are accountable, responsible and explainable

India has a multicultural society whose population has varying levels of education and income. Therefore, AI development and deployments, particularly in areas affecting a wide section of the population, such as civil services, must fall within the purview of the legal, cultural and ethical precedents applicable to the geography in question.

AI systems should be developed to operate in a responsible manner such that their outcomes do not adversely affect individuals or marginalise one or more sections of society. Responsible AI ensures that its workings are aligned to ethical standards and social norms pertinent within its scope of operations. For example, in military and defence, the use of AI in combative equipment and robots must be aptly governed by laws of armed conflict and mandates such as International Humanitarian Laws (IHLs).

Over 50 scientists from across the globe had called for a boycott of a renowned university in South Korea which was undertaking research on AI-based command and decision systems such as autonomous weaponised sentry robots utilising smart object tracking and recognition. Cases such as these highlight the need for greater transparency so that all parties are in agreement with AI research goals and deployment scenarios.[57]

At the same time, AI systems need to incorporate an explainable design. Explainable AI designs ensure that the inner workings of an AI system are transparent and well understood by the system owners and administrators, and its outcomes can be explained beyond reasonable doubt or ambiguity. Explainable AI is responsible for building AI models with accountability and the ability to describe or depict why a certain decision was made by the algorithm.[58] This is especially important to establish public trust in AI systems and smoothen the assimilation of AI lead workflows across different processes.

In order for AI to be perceived as responsible and explainable over time, AI systems would need to be made robust against attempts of outcome manipulation whether through contamination of training data or algorithmic tampering.

The above reasons will necessitate the formation of independent audit bodies and ethics panels to screen research proposals, design and develop, and commercialisation and periodic review and maintenance of AI systems.

Finally, it will be important to explicitly define performance standards (and conduct timely evaluations against the same) and document plans of action for scenarios where AI systems operate in a manner deviating from their intended functioning so that anomalies, should they arise, can be identified, responded to and remedied at the earliest.

57 Hutson, M. (4 April 2018). South Korean university's AI work for defense contractor draws boycott. Science Magazine. Retrieved from http://www.sciencemag.org/news/2018/04/korean-university-s-ai-work-defense-contractor-draws-boycott (last accessed on 10 April 2018)

58 Gunning, D. (n.d.). Explainable Artificial Intelligence (XAI). DARPA. Retrieved from https://www.darpa.mil/program/explainable-artificial-intelligence (last accessed on 10 April 2018)

5.5. Managing the impact of AI on employment

Previous technological revolutions have resulted in the shuffling of peoples' job profiles, markedly characterised by a shift away from monotonous and repetitive work and towards high-involvement roles requiring human judgement and interactions. With the initiation of automation and implementation of AI in organisations, there have been concerns regarding job displacement.

While **65%** of the participants from PwC's 2018 AI impact research survey[59] indicated their belief that AI will have a severe impact on employment in India, **55%** stated that the benefits of AI for businesses, such as growth generation and productivity boost, would outweigh potential employment-related concerns.

Further, over **60–70%** of the participants indicated that they would prefer AI-enabled models that offer improved service and are more affordable over traditional models— for example, affordable and convenient autonomous transport over transport operated by traditional human drivers and affordable intelligent legal services and customer service solutions over traditional human-led models. While employment-related concerns cannot be dismissed altogether, there is likely to be a shift from traditional jobs to more evolved, high-involvement roles for humans in the future as efficiency, safety and standardised quality are expected to take precedence in certain services over the natural course of development.

A recent report published by the Artificial Intelligence Task Force[60] pegs (based on estimates cited in various Indian publications) the AI industry in India to be worth **180 million USD**. **Thirty-eight percent** of AI professionals are employed with large-sized companies and **33%** with start-ups. Bengaluru as a city alone accounts for around **37%** of AI-related jobs, followed by Delhi NCR and Mumbai, together accounting for **36%** of the jobs.

Furthermore, in the discourse on the potential impact of AI-powered automation on the workforce, it would be pragmatic to recognise 'lump of labour'[61] or 'fixed-pie' fallacies (i.e. the idea that there is a fixed amount of labour requirement within an economy which can be distributed— in this case, between humans or machines to increase or decrease jobs). The slow adoption of AI could pose a greater risk to economic growth and employment opportunities in the future as trade investments get channelled towards more advanced, efficient and cost-competitive economies.

AI is expected to create new areas of economic opportunity and wealth creation, which will be an ingredient in retaining key sectoral competitiveness and, in turn, jobs.

The 'Report of the Task Force on Artificial Intelligence' has also highlighted a few noteworthy cases of new jobs that may be created by AI. They include:

- **ML schools** – where humans may apply their innate cognitive skills such as recognising images and faces and interpreting language and speech to generate data for training machines.

- **Advisory solutions in human-AI collaboration** – opportunities to compress human expertise and knowledge via ML into computerised advisory solutions. These might be particularly beneficial for agriculture, rural healthcare and financial advice.

- **Greater levels of involvement of healthcare professionals** – AI may free up physicians, nurses and other care providers to apply themselves more intensively to the interactive, humane and empathetic side of care delivery and also to prioritise their time and expertise towards critical cases.

- **Creation of new roles within IT services** – AI-focused automation and the shift in IT service requirements may see a relative move away from jobs like research analysts, data entry operators, system engineers and test engineers towards newer roles such as AI research scientists, language processing specialists, RPA developers, and man-machine teaming managers.

Given the widespread engagement of the Indian workforce in IT services and BPOs, the impact of AI-enabled automation, over the short term, is expected to be high. Overseas clients have been the mainstay in terms of revenue generation for many Indian IT behemoths. As these clients employ intelligent automation for 'no-shoring' or 'in-shoring'—that is, bringing processes back in-house—the Indian IT services industry would need to re-skill a large part of its workforce in AI and ML solutions and offerings to mitigate potential job losses.

59 PwC. (2018). Artificial intelligence in India – hype or reality. Retrieved from https://www.pwc.in/consulting/technology/data-and-analytics/artificial-intelligence-in-india-hype-or-reality.html (last accessed on 10 April 2018)

60 Kamakoti, V. & others. . (20 March 2018). Report of the Artificial Intelligence Task Force. Department of Industrial Policy and Promotion. Retrieved from http://dipp.nic.in/whats-new/report-task-force-artificial-intelligence (last accessed on 10 April 2018)

61 The Economist (adapted from Essential Economics by Matthew Bishop). (n.d.) Lump of labour fallacy. Retrieved from https://www.economist.com/economics-a-to-z/l (last accessed on 10 April 2018)

5.6. Re-skilling the workforce for new-age employability

The breakneck pace of innovation in AI and robotics has posed a challenge for academics and businesses, leading to the need for trained personnel to create, maintain and permeate AI and ML solutions. This has translated into the need for skilled professionals who understand the sector and domain, are able to analyse its data effectively, and for individuals with deep technology skills in data manipulation and statistical modelling, which form the backbone of innovations in AI.

While data science and programming competencies are invaluable skills for new-age tech (AI, ML and robotics), specific skill sets on algorithms—the base of these technologies—are emerging as game changers.

According to PwC's 20th CEO Survey, 52% CEOs are already exploring the benefits of humans and machines working together and 39% are considering the impact of AI on their future skills needs.[62]

The skill sets expected to be held by the workforce of the future can be broadly classified into the following categories:

- **Technology, algorithmic and programmatic know-how:** This is required to conceptualise, design and implement systems and applications that make use of either one or more areas within AI (ML, natural language processing and generation, video and speech analytics, etc.) to transform business processes and workflows.

- **Strategic and operational decision making:** This would be required to put into action insights gained from applications using AI for enhancing performance, reducing costs, gaining competitive advantages and furthering social causes.

The demand for skills in AI and data science has grown substantially over the last 3–5 years. These skills are no longer confined only to the technology sector but are also of importance in banking, retail, healthcare and other sectors.[63]

Leaders of AI and ML start-ups and established firms have indicated[64] time and again that they are facing a dearth of applicants for their advertised positions. The shortage of expertise and the lack of talent in robotics, ML and advanced analytics is also creating challenges for entrepreneurs.

Co-founders of a prominent AI firm in India indicated that nearly 40% of their working time is spent searching for the right talent.[65]

While India is home to a large number of engineers graduating from colleges every year (with a big proportion of them specialising in IT), their skill sets—a result of their curriculum—are centred more on traditional software and applications as opposed to R&D in the field of new age technology.

India—an arguably late entrant into the AI and robotics space—will be required to expedite the skilling of its talent base to match the current level of demand.

Only a very small percentage of AI personnel in India have hands-on experience in cutting-edge technologies like deep learning and neural networks, which are a mainstay for advanced analytical solutions. – A recruitment start-up[66]

New-age technologies such as AI and robotics usually only have a minimal knowledge dependency on legacy technologies such as language, platform or system. Hence, one may, if he/she chooses, pick up these new-age technologies with proper study while skimming through traditional programming or software applications. However, it might help to have certain basic knowledge of programming to speed up the learning process.

It might prove to be cost-effective and rewarding for organisations to strategically partner with academic institutions, wherein experts in the fields of AI and ML may be brought in to train employees who are new to these technologies and thus diffuse knowledge in a way that helps employees quickly understand, retain and apply as much knowledge as would be required to perform the job at hand.

62 PwC. (2017). The talent challenge: Harnessing the power of human skills in the machine age. Retrieved from https://www.pwc.com/gx/en/ceo-survey/2017/deep-dives/ceo-survey-global-talent.pdf (last accessed on 10 April 2018)

63 Narayanan, C. (2017). The skills shortage. The Hindu Business Line. Retrieved from http://www.thehindubusinessline.com/opinion/columns/chitra-narayanan/the-skills-shortage/article9799112.ece (last accessed on 10 April 2018)

64 Punit, I. S. (2017). Indian engineers need to stop being so afraid of the term "artificial intelligence". Quartz India. Retrieved from https://qz.com/911261/indian-engineers-need-to-stop-being-so-afraid-of-the-words-artificial-intelligence/ (last accessed on 10 April 2018)

65 Ibid.

66 IANS. (21 June 2017). Acute talent shortage in AI, IoT industry, shows survey. Economic Times (Technology). Retrieved from https://tech.economictimes.indiatimes.com/news/technology/acute-talent-shortage-in-ai-iot-industry-shows-survey/59254799 (last accessed on 10 April 2018)

Role of individuals

Considering the pace at which technology is evolving, it may be difficult to predict the skills that will be needed even five years from now. Hence, employees and businesses need to be ready to adapt. Inevitably, most of the responsibility will be borne by an individual, who will be required not only to adapt to organisational change but also to acquire new and upcoming skills and capabilities throughout his/her lifetime. This will help him/her in learning new tasks and even retraining himself/herself at the middle of his her career.

Seventy-four percent of employees are ready to learn new skills or completely retrain in order to remain employable in the future. They believe that it's their own responsibility to update their skills rather than relying on any employer.[67]

Role of educational institutions

Considering the changes in the technology landscape and in companies, academic institutions need to play a role in skill development by creating an interface for students to connect with industry professionals. Academic institutions can also encourage and inspire students to work in the industry sector on different real-life challenges pertaining to current technologies and practices. These initiatives will help organisations to evaluate their prospective employees and students to get more hands-on industry experience.

Another activity that academic institutions could undertake is upgrading their curriculum, workshops and laboratories with the current industry requirements. Advanced technology infrastructure and equipment have been installed in a few premier institutions. This should be replicated across other institutions as well.

Role of businesses

As the use of AI increases within companies, it would help if employees are aware about the complete AI ecosystem rather than only their function. A unique way for tech companies to increase the number of jobs available to people could be by using technologies such as cognition and natural language processing and generation to break down interconnected systems and tasks and, as a result, sieve out creative and innovative tech jobs for humans.

Innovation will play a significant role for businesses in the future. Fostering a culture of innovation driven by rewards and recognition has become vital for organisations to identify solutions to their challenges and use technology to address them.[68] Timely skill development of employees through training will ensure smooth transition into new roles within a digitally transformed organisation.
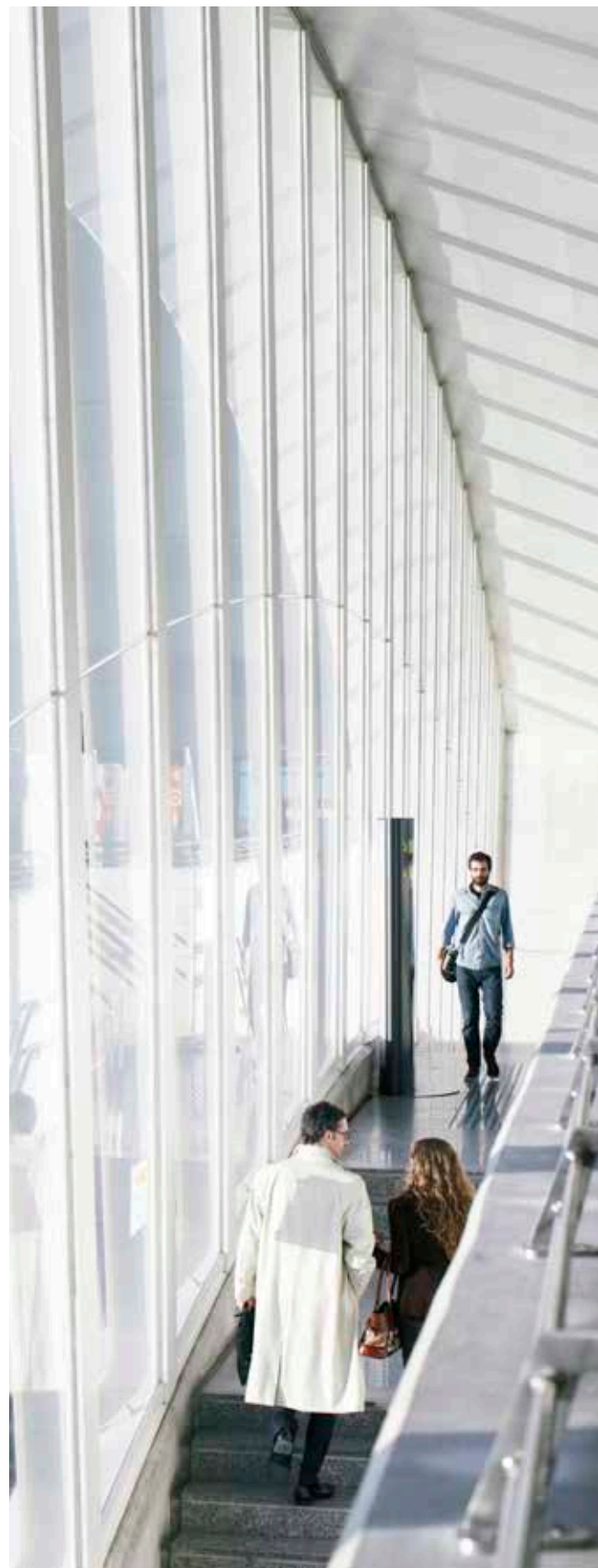
67 Stubbings, C., Williams, J., & Brown, J. (2017). Workforce of the future - The competing forces shaping 2030. PwC US. Retrieved from https://www.pwc.com/gx/en/services/people-organisation/workforce-of-the-future/workforce-of-the-future-the-competing-forces-shaping-2030-pwc.pdf (last accessed on 10 April 2018)

68 Basu, A., Chakrabarti, D., & Chakrabarti, A. (2017). Success stories and the road ahead technology-enabled manufacturing. PwC. Retrieved from https://www.pwc.in/assets/pdfs/publications/2017/success-stories-and-the-road-ahead-technology-enabled-manufacturing.pdf (last accessed on 10 April 2018)

6. The road ahead – policy planning priorities for the future
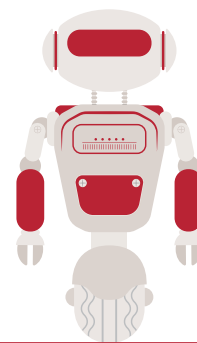
The government and organisations should not use AI, ML and other new-age technologies just because others are using them. Instead of being followers, organisations need to identify a strategic need for AI such that it can solve their business problems and benefit them.

6.1. Drive cross-border collaboration with countries leading in AI research

Countries across the globe have already established strategy councils or similar government bodies to facilitate and direct AI research and innovation towards meeting social and economic objectives.

Forming cooperative relationships with some of the frontrunners in AI—such as Japan, the UK, Germany Singapore, Israel and China—to develop solutions that tackle social and economic challenges can aid and accelerate strategy formulation. Exchanging best practices and learnings from prior initiatives is one way of strengthening cooperation. Government departments like the Ministry of External Affairs and Department of Science and Technology may take the lead in developing such relationships.

In Japan, the Strategic Council for AI Technology[69] detailed a projected industrial roadmap driven by a combination of AI and related technologies while calling for the collective wisdom of the industry, academia and the government to accelerate the path from R&D to social implementation. The report also identifies 'productivity', 'health and medical care', and 'mobility' as the three priority areas for AI based on perceived social necessity and expected contributions from AI.

China has been making strides in AI. With an already booming manufacturing sector, the natural next step is expected to be technology enablement of the sector—an area where AI and robotic automation can bring the next economic miracle for the country. China's 2017 'New Generation AI Development Plan'[70] issued by the State Council of the People's Republic of China stresses healthy and sustainable AI through an open, cooperative innovation system with further emphasis on predicting the challenges of AI, coordinating with industrial and social policies, reasonable regulation and risk prevention to maximise the benefits of AI.

69 Strategic Council for AI Technology. (2017). Artificial intelligence technology strategy. Retrieved from http://www.nedo.go.jp/content/100865202.pdf (last accessed on 10 April 2018)

70 Webster, G., Creemers, R., Triolo, P., & Kania, E. (1 August 2017). China's plan to 'lead' in AI: Purpose, prospects, and problems. Retrieved from https://www.newamerica.org/cybersecurity-initiative/blog/chinas-plan-lead-ai-purpose-prospects-and-problems/ (last accessed on 10 April 2018)

6.2. Create enabling environments for AI-led growth

Policy planning in AI must be aimed at creating an ecosystem that is supportive of research, innovation and commercialisation of applications.

While academia and the private sector focus their research activities on finding applications with diverse usage, the public sector, with its various schemes (Digital India, Make in India, Skill India, etc.), could identify areas where specific applications of AI and robotics can be utilised to increase reach, effectiveness and efficiency, thus giving direction to existing innovation across different fields.

Regular cooperation will be required between academia and the public and private sectors in order to identify and get a comprehensive view of problems faced by the population and find intelligent and innovative ways to increase the efficiency and effectiveness of services delivered to society. An increase in the number of public-private partnerships across industries and social projects is expected. These partnerships will be aimed at utilising the latest tools and techniques in AI to further the objectives of inclusive growth.

Some of the initiatives to bolster such an environment could be collecting quality training data (e.g. from public portals) and making it available for research and educational purposes. A centralised approach to this may require setting up of digital data banks and exchanges to stream in information from across industries.

Further, secondary school and university curricula need to be revised in order inculcate an interest in AI and its constituent areas. This will lead to higher rates of students actively pursuing higher education and careers in these fields.

Another enabling factor for AI growth would be setting up centres of excellence supporting inter-disciplinary research across law, medicine, engineering, management and the social sciences. Japan's national R&D institute, 'Riken',[71] can serve as a comparative model. The institute conducts research in a broad array of areas such as engineering, medical science and high-performance computing while pooling resources like hardware, computing power, infrastructure and talent.

6.3. Strengthen data ownership, privacy and security frameworks

AI, ML and robotics are largely dependent on volumes of data. As a result, devices and applications making use of these technologies are designed to continuously capture and relay user information.

In such a scenario, it becomes imperative to have a strong policy outlining how and when companies can capture, process and share individual data with third parties. In a healthcare setting, for example, governing policies could lead to privacy breaches owing to the collection and sharing of patient medical history by hospitals with other companies or agents without a patient's consent.

Similarly, policymakers could put in place mandates that require cloud service providers to guarantee service levels and physical locations of data centres used for their customers (public and private) and provide adequate compensatory cover in case of data loss or corruption.

For AI and robotic applications and platforms, especially those that function autonomously, such as self-driving cars and predictive profiling, establishing robust legal and ethical boundaries through policies could direct developers and leaders of AI firms so that their products are responsible, transparent and meet the checklist of acceptable conditions before they are launched in the market.

AI research and AI-based systems are highly interdisciplinary in nature and would require standards of operation involving multi-domain expertise. Some of these include established guidelines for data storage, privacy, communication protocols for automated systems and interoperability between systems. In this context, India's participation in international standard-setting groups for AI systems and the role of bodies like the Bureau of Indian Standards will be crucial.

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71 Riken (official site). Retrieved from http://www.riken.jp/en/about/ (last accessed on 10 April 2018)

6.4. Extend financial and non-financial incentives to boost AI growth

A more direct approach by the Central and state governments could be fiscal and non-fiscal incentives. Non-fiscal incentives may include full or partial exemptions from acts related to wages, inspections and shift operations. Fiscal incentives may include partial reimbursements of lease rentals, bandwidth and connectivity, coverage of fixed power costs to the entity, full or partial reimbursements of set-up and operational costs such as stamp duty, transfer duty, registration fees, patent filing costs, quality certifications, skill upgrade and training costs, and subsidisation of capital investments, property taxes, insurance premiums and maintenance charges.[72]

Further, policy initiatives could include the hosting of industry events to recognise and award breakthrough innovations in AI, ML, robotics, IoT, the cloud, and virtual reality (VR) and augmented reality (AR). This will garner participation from established firms, SMEs, start-ups, institutional teams and amateur developers, thus building awareness and enthusiasm towards different technologies in the process.

The above incentives would, however, require a framework and a set of standards to aptly classify and certify firms and projects as genuinely AI based and with actual potential for addressing social relevant goals so that such incentives can gain higher returns.

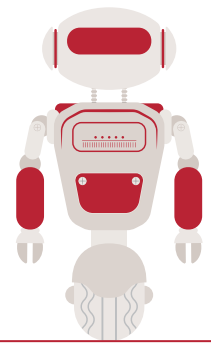## 6.5. Leverage opportunities to shorten time-to-deploy for AI-powered solutions

In line with the ideology that AI development and innovation must be aligned towards addressing the larger issues faced by businesses and society, there is a need for a practical and pragmatic approach towards AI use. Wherever it can be done effectively, cost-consciously and with due consideration to national interest, opportunities to partner with AI leaders, be they technology leaders or public bodies in countries across the globe, should be sought out to set in motion pilot applications that utilise AI to bring short-term, tangible and measurable benefits.

For instance, the government could act as a catalyst in furthering growth by opening training centres focused on equipping young individuals with high-end skills in the field of analytics and ML, which, in turn, could be tied in with inviting data-driven global enterprises to set up their centres of excellence in India. This could be an extension of the Digital India and National Skill Development initiatives to meet the growing demand of analytical and AI competency. The outcome from such partnerships could be beneficial to the firms in question as well as the country's human capital.

Within the private sector, larger firms can form strategic alliances with start-ups and SMEs operating in the space to further accelerate development and commercialisation opportunities. Start-ups and SMEs can bring down their capital investment by using technology on a shared basis. Established companies can bring affordable technology solutions to start-ups and help them upgrade and adopt new technologies in a short span of time. In turn, these start-ups could act as the technology research arm of one or more established firms and supply developed applications to these larger firms at lower costs than they would to other players. This would help in the formulation of 'symbiotic clusters' of AI and robotics innovations. The same could hold true for groups of technology start-ups sharing infrastructure and technology resources.

In conclusion, progress in AI, ML and robotics should follow the needs of businesses and individuals rather than the other way round. In order to ensure that innovation is directed towards effective pursuits and does not clash with human interests (for example, by introducing biases in outcomes), collaborative efforts and ongoing dialogue between the three pillars of AI-based research—academia, the public sector and private sector—should be encouraged.

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D. S. Rawat
Secretary General
d.s.rawat@assocham.com

The Associated Chambers of Commerce and Industry of India (ASSOCHAM)

Corporate Office:
5, Sardar Patel Marg, Chanakyapuri
New Delhi - 110 021
Tel: 011-46550555 (Hunting Line)
Fax: 011-23017008, 23017009
Website: www.assocham.org

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About the authors

This knowledge paper has been co-authored by Prasun Nandy, Indranil Mitra, Udayan Bhattacharya, Shruti Kakar, Deboprio Dutta and Neelam Patodia. Prasun Nandy and Indranil Mitra are Directors in PwC's Data and Analytics practice and focus on AI. Udayan Bhattacharya is an Associate Director and works on AI, ML and cognitive automation along with Shruti Kakar, Deboprio Dutta and Neelam Patodia.

Contacts

Arnab Basu
Partner and Leader
Technology Consulting, PwC India
arnab.basu@pwc.com

Sudipta Ghosh
Partner and Leader
Data and Analytics, PwC India
sudipta.ghosh@pwc.com

Prasun Nandy
Director
Data and Analytics, PwC India
prasun.nandy@pwc.com

Indranil Mitra, PhD
Director
Data and Analytics, PwC India
mitra.indranil@pwc.com

Udayan Bhattacharya
Associate Director
Data and Analytics, PwC India
udayan.bhattacharya@pwc.com

Shruti Kakar
Senior Consultant
Data and Analytics, PwC India
shruti.kakar@pwc.com

Deboprio Dutta
Senior Consultant
Data and Analytics, PwC India
deboprio.dutta@pwc.com

Neelam Patodia
Consultant
Data and Analytics, PwC India
neelam.patodia@pwc.com

pwc.in