

Changing roles of information and communication technologies in India

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Abstract

Information and communication technology (ICT) is encompassing all the areas of commercial activities and government-citizen interactions. ICT is an important contributor to the economic development, human welfare and there are various agencies and organizations monitoring and measuring statistical impact of ICT. This white paper aims to categorize positive impact of ICT in terms of productivity and growth in the developing countries such as India. Developing countries like India suffer from digital divide and ICT helps to overcome that divide. Digital divide creates artificial classes in the rich and the poor and even creates classes in the masses. This white paper discusses impact of ICT on India, what empowerments and enablement are needed and what opportunities lie ahead for India. This white paper takes cognizance of current initiatives and how government, industry, organizations and citizens need to work cohesively and push for maximum utilization of ICT to boost benefits of new technologies to all the strata of the society.

Keywords: India, economic development, ICT, e-Government, e-Governance, artificial intelligence, big data, machine learning, analytics, IoT

1. Prologue

Adequate ICT capability is the precondition for any country's progress as an innovation economy. For countries which aim to decrease their global income gap, the promises of ICT are obviously attractive. ICT helps such countries to increase their reach to rural and urban areas so that government's schemes can reach to desired geographic areas and help in reduction in poverty levels (Chandrasekhar, 2001). Indian Council for Research on International Economic Relation (ICRIER) report claimed that internet usage positively impacts GDP. It had also been acknowledged that almost 10 percent increase in internet and mobile traffic resulted in increase of 3.3 percent and 1.3 percent respectively of India's GDP (Kathuria et al., 2017).

The aim of this white paper is to discuss the benefits of pervasive use of information and communication technology (ICT) and impact of ICT for the overall development of India.¹⁾ This white paper analyzes the emergence of ICT strategy in India and areas that may need special focus and attention of all the stakeholders to make it a globally competitive and efficient ecosystem for the betterment of India's citizens.

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1) Benefits of e-HRM in India were discussed by Bhadoriya and Patwardhan (2018)

This white paper also considers aspects of India's rich and poor divide and being multi-cultural, multi-lingual (23 languages, 325 spoken languages and 1652 dialects) and multi-religious country with complex socio-economic conditions. India is a vast country with 1,295 million population and geographical area of 3.28 million square kilometers. India's GDP is 2.4 trillion US dollars. Such a vast country provides its own challenges in each area of governance and we see ICT as a key tool in Indian's arsenal to tackle at least some of the problem areas for the current and future generations. Key challenges which will be discussed in this paper are a) diversity, b) rural – urban divide, c) talent pools, e) multiple agencies dealing with ICT, d) other factors hampering ICT growth. This white paper will also discuss how US \$167 billion Indian IT industry and 3,500+ strong startups are enabling stronger ICT push.

2. Overview

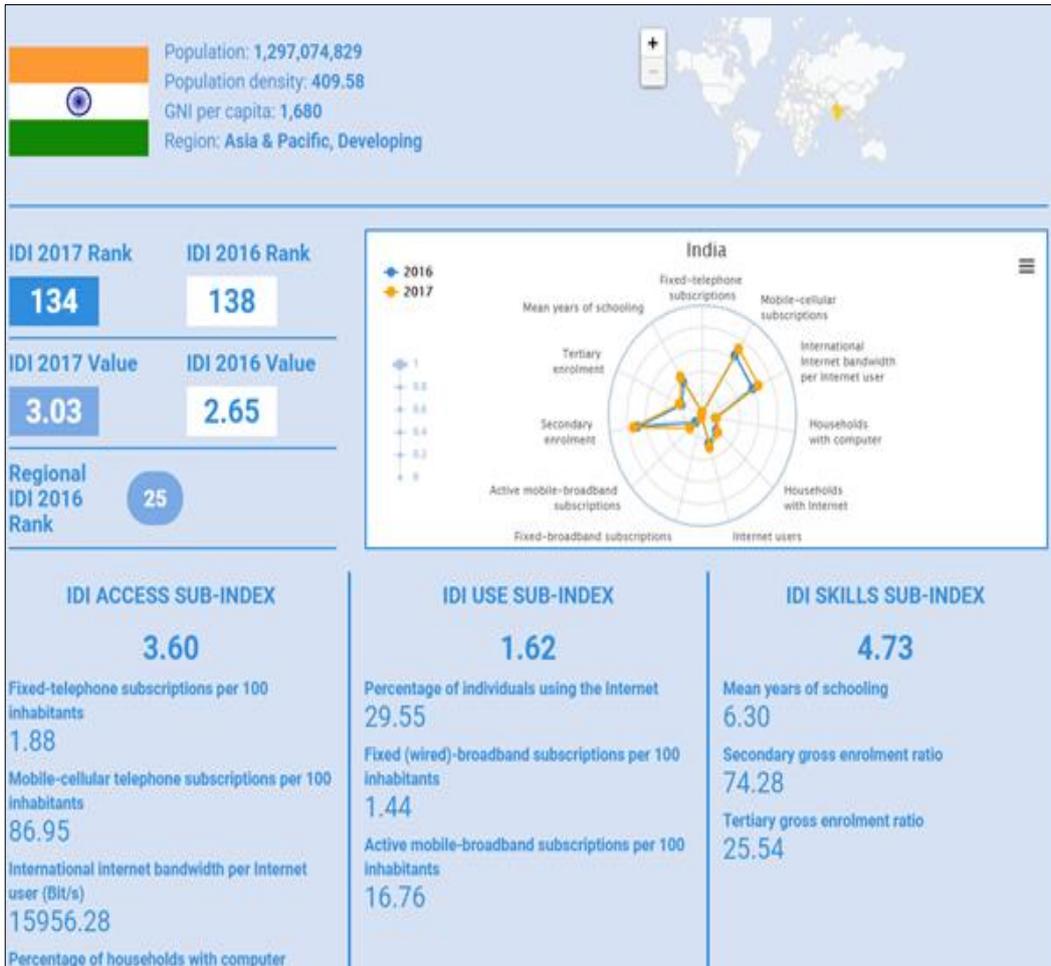
Today, the world is at convergence of information and communication technologies. The convergence is aiming to make the world better through more pervasive services for the people. With the invention of new technologies, there is a huge scope of development in all the business domains or sectors to harness the power of combined technologies for the betterment of India. Newer technologies are bringing world together for efficient utilization of available scarce resources and towards sustainable goals. Technology is bringing a marked and need driven change in realignment of government spending, market forces and their alignment for the greater good. ICT is providing a foundation for rapid upliftment in several areas such as digital education, fraud detection, anti-money laundering, digital payments, risk and regulatory compliance to name a few. ICT enhances workforce productivity and provides innovative ways of improving economic aspects and development of the country. Government of India has realized this transformative change which is coming up and has made significant investments in this sector. Government of India is heavily relying on ICT to enable early capture of economic factors data which shape up the tactical and strategic policy and investment decisions.

India started opening its economy around 1991 (Venkatanarayanan, 2015) and since then it has made large strides in several economic areas. The economy didn't remain closed and protective as it used to be, enabling large foreign institutional, research organizations and governmental cooperation. Indian organizations and global organizations are now much better connected and have established good rapport. To take India closer to be a developed nation (Economic Times, 2018), India needs to become an efficient and competitive economy. The ICT strategy of a nation is always a very crucial indicator to measure and control. It is very important that the ICT strategy and policies of a nation must not only be suitable but should also believe in a "holistic measurable controllable application and implementation". The ICT strategy and policy of a nation cannot afford to keep different components of ICT separate. Their amalgamation and supplementation must be done on a priority basis otherwise the ICT strategy and policy will not bring the desired results. The present ICT strategy and policies of India are somewhat deficient and need more work in some respects as discussed later in this paper. This is quite evident from the India's ICT ranking given by International Telecommunication Union (ITU) for ICT Development Index (IDI) for year 2017 as shown in Figure 1. India's IDI rank has been improving since 2016 and India is confident of its further improvement based on the work being undertaken in this direction. IDI rank is a key indicator for the government agencies, operators, development agencies, researchers to measure the digital divide (Borbora, 2004). An organization for Economic Cooperation and Development (OECD) article in 2011 defines the term "digital divide" as the gap between individuals, households, businesses, governmental spends and geographic areas at the different socio-economic levels regarding their opportunities to access information and communication technologies (ICTs) and their use of Internet. As the discussion

below, it may be noted that digital divide is reducing in India and the government and private partnerships are helping bridge it further (Singh, 2010).

From the diagram in Figure 1 key predictor and indicator variables which need significant attention and investment are: a) Internet bandwidth per internet user, b) households with computing devices, c) households with internet access, d) mean years of schooling and gross enrollment in schools. Figure 2 shows increasing penetration of the computers, phones and internet across India.

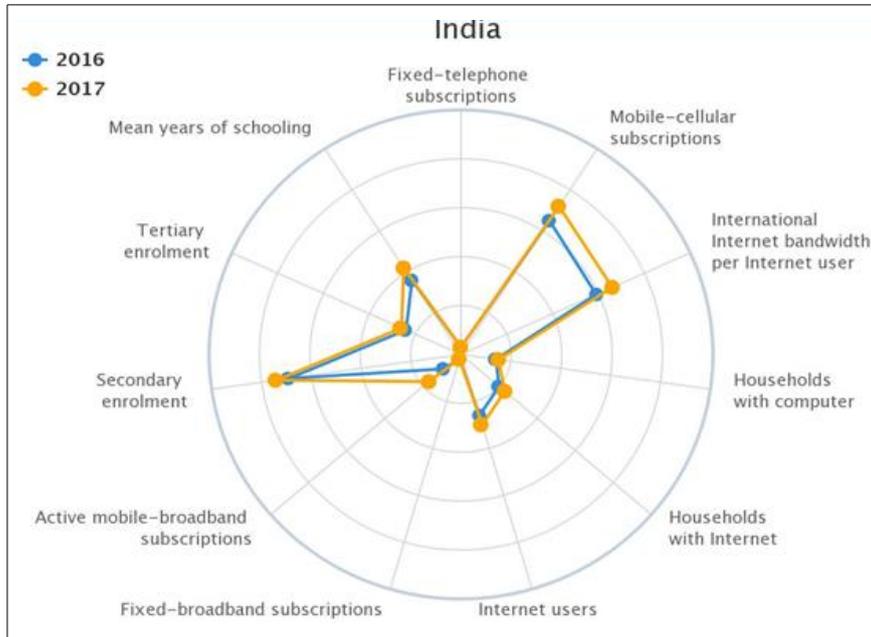
Figure 1. India ICT 2017 ranking



Source: ITU. (n.d.)²⁾

2) <http://www.itu.int/net4/itu-d/idi/2017/index.html#idi2017economytab&IND>

Figure 2. Blown up chart from Figure 1



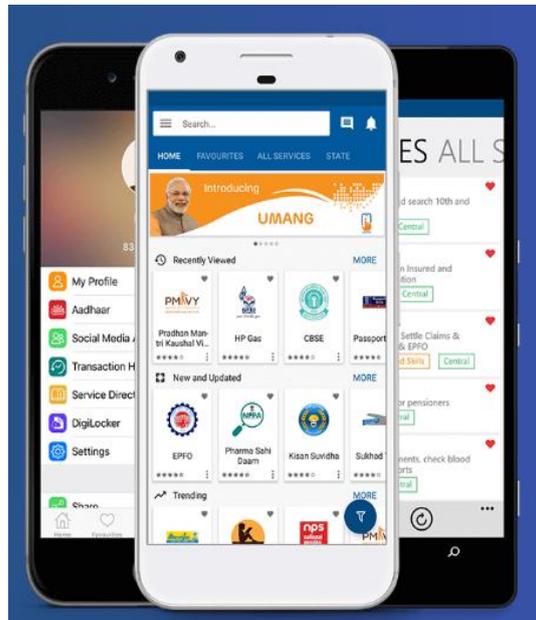
Thus, the Indian government has now renewed focus on the ICT area and has started making significant investments to influence desired outcomes. The proposals from the government are a comprehensive set of actions and tasks that try to balance hard ground realities and demands of the next generations. The aspirations of the Indian citizen and diaspora are to propel India in standards which are at par with the developed western countries. The government now is focusing on principles of “connect and boost” to get India rapidly in the first 50 ranks in the ITU ICT index (Mukherjee and Chawla, 2018).

The Indian government also needs to focus on smartphones which are most common and popular computing device which most of the Indian population has. Today’s smartphones are much more powerful than yesteryear’s high-end computing devices in terms of cores and memory. Smartphones are helping common and rural people bridge the digital divide. We will see in the later sections of the paper on how the various measures including mobile technologies being undertaken at different levels. Technologies like Big Data, Analytics, artificial intelligence (AI), Internet of Things, advanced visualization technologies will spawn a supporting ecosystem and significant transformations in India. These technologies are being increasingly leveraged for improving B2B, B2C, C2C, G2C and G2G interactions and communications by improving human experience. ICT in India is fast ushering in organizations towards the fourth industrial revolution and slowly towards the fifth industrial revolution. The United Nations also recommends one of its Sustainable Development Goals to significantly increase access to ICT and strive to provide universal and affordable access to the internet in the least developed countries by 2020. This goal is now within reach and clearly visible in India with the rise of high speed 4G and experimental 5G technologies from vendors like Reliance *Jio*, Airtel, Vodafone, etc. Internet speeds of 4G in rural are now increasingly common and urban areas are seeing speeds of 100Mbps+. Investments in broadband consumption and access enablement for example can pay richly by improving GDP directly. Important factor to be considered here is that tele-density (number of telephony/mobile connections

for every hundred residents) has jumped approximately 48 times in rural areas and 14 times in urban areas in a period of 14 years from the year 2000 onwards as per the survey conducted by Telecom Regulatory Authority of India³⁾. In 2013, more than 180 million subscribers used mobile based Internet connectivity. In 2017, the subscriber base has grown up to 1,192.14 million and tele-density has reached 92.01%. The Internet subscriber base is now 429.23 million. This provides a significant and necessary boost for bridging the digital divide and enabling newer channels of customer interactions. Authors of this study based on academic and industrial experience of more than 20 years suggest that governmental agencies and other stakeholders take steps to facilitate the journey from ICT being a just infrastructure layer to be a key enabler in the journey from just being a social awareness tool to services adoption (like e-Governance services) to digital transformation journey for Indian enterprises and empowering tool ecosystem for the downtrodden and least privileged.

Focus of the current Indian government on electronic governance is bringing a sea change in the way governments and the public interact for rural as well as urban populations. E-Governance services are providing faster and efficient services to the households. One such very good example of this is the *Umang* mobile application launched by the central government (shown in Figure 3 below). This application integrates services for Indian unique identifier *Aadhar*, DigiLocker, PayGov, My PAN (permanent account number for the Indian Income Tax department), Employee State Insurance Corporation, Public Health Engineering Department, Prime Minister's health scheme, Central Board of Secondary Education, Smart Cities, etc. Aadhar started as a foundation of the identity digitization initiative and was a significant first successful step towards digitization. Indian government's effort to make India cashless by employing digital technologies – Unified Payment Interface (*Bharat* Interface for Money - BHIM) is a nice example of governmental push towards digital economy and reducing parallel/black economy.

Figure 3. Umang application



3) <https://data.gov.in/catalog/teledensity-india>

Unified Mobile Application for New-age Governance (UMANG) is developed by Ministry of Electronics and Information Technology (MeitY) and National e-Governance Division (NeGD) for fostering the e-governance in India. Umang makes it possible to avail government schemes to citizen of India at most convenient and cost-effective way.⁴⁾

For Indian businesses, advances within ICT have brought a variety of opportunities and efficiencies due to cost savings, improved supply chain management, efficiencies ranging from highly automated business processes and management thereof which have highly cut costs. There is also the big data analytics revolution where organizations are mining the vast trove of data generated by ICT into insights that drive new products and services and get better customer intimacy, to ICT-enabled transactions such as online B2B/B2C e-Commerce, telemedicine and social media based user outreach capabilities that give customers more choices in how they shop, communicate and interact enabling better customer intimacy to the organizations in turn. Organizations are also turning from being data wasters to data collectors to data harvesters which is a very healthy trend for such a vast country like India.

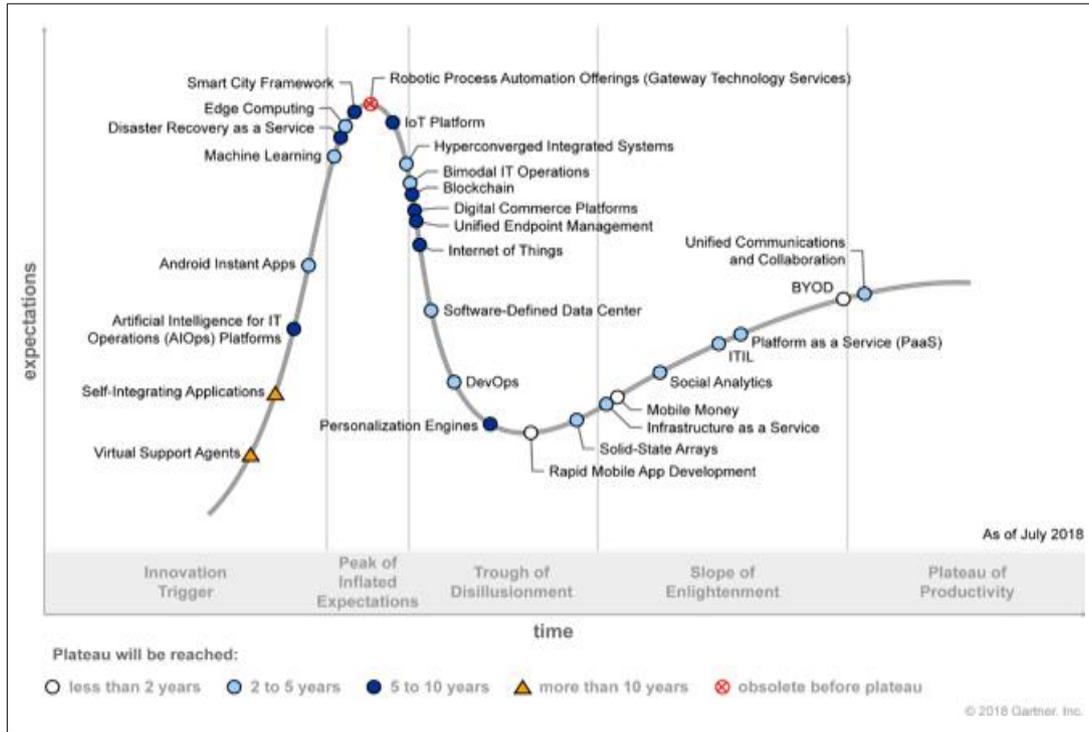
3. Paradigm shifts in the ICT area in India

ICT typically involves grouping of technological areas such as hardware, software, networking, etc. Some of these areas are progressing by leaps and bounds. Indian ICT is seeing winds of change due to emergence of newer technologies such as Internet of Things, blockchain, artificial intelligence, edge computing, cloud computing, mobile and digital payments platform, wearables, smart cities and robotic process automation (RPA) to list a few. There is also a wave of underlying foundational innovations which are enabling these shifts such as Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a Service (IaaS), Software Defined Networks (SDN) and Data Centers as a Service. Indian IT organizations as well as the Indian Government and its agencies are quickly closing gaps with the advanced and developing countries all over the world. This means that trends and innovations are echoing trends in the western worlds, however, it must be noted that Indian customers are typically risk averse and tend to adopt latest technologies at a slower pace than their global counterparts. It will be an important initiative to predict benefit of each new emerging ICT area and expediting time for widescale adoption of such technologies.

Technologies such as artificial intelligence (including augmented and ambient intelligence), Internet of Things (IoT), Big Data Analytics and blockchain especially are truly transformational and will have wider societal impacts on the population of India. Indian organizations have pushed the demand for increasingly smart, proactive, intelligent, immersive user experiences and products from the customer's Quality of Experience (QoE) point of view. This QoS view must be matched by the Quality of Service (QoS) view from the content and service providers. This merging of two quality views will benefit both sides in terms of quicker time to market, agility, and improved quality due to closer customer intimacy. The Indian government needs to shape up the ICT strategy so that interests of all stakeholders are preserved and must ensure that strategy is inclusive. The policy gives boost to service improvement, innovation, cost reduction, competitive boost for industries and risk mitigation. Gartner Hype Cycle in Figure 4 clearly highlights importance of three critical technologies for India which are machine learning, edge computing and platform-as-a-service.

4) <https://web.umang.gov.in/web/#/>

Figure 4. Gartner Hype Cycle for ICT in India, 2018

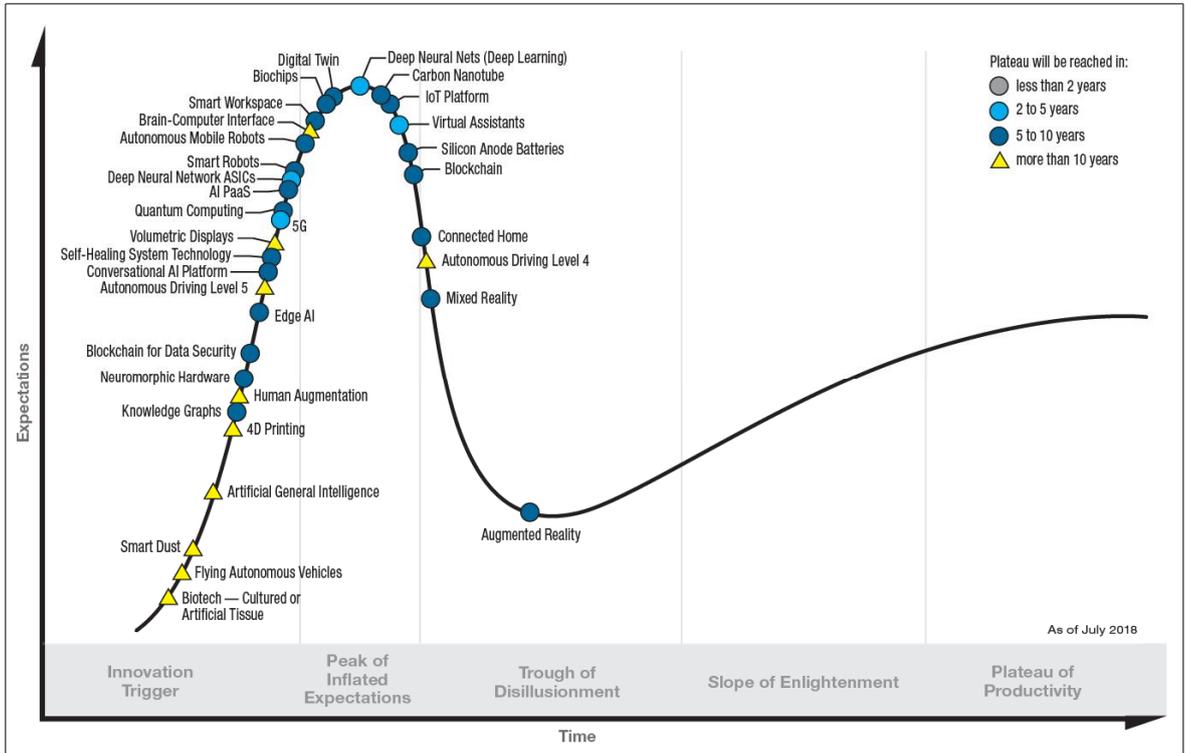


Source: Gartner (2018)⁵

Gartner's second hype cycle for emerging technologies (shown in Figure 5) mentions these technologies as things to watch for. Authors of this paper based on their rich academic and industrial experience believe that following technologies will have strong showing in the next two years, and then the whole gamut of technologies cited – Conversational AI, Edge AI, digital twin, deep learning & advanced neural networks, self-healing systems, and augmented reality will further boost ICT spread. AI is becoming widely available due to high performance enterprise and personal computing systems, smart mobile devices, availability of larger data corpuses, data democratization and of course due to increasing demand from the business to move from hindsight (reactive analytics) to insights (predictive analytics) to foresight (descriptive analytics). Key business stakeholders also want to move away from knowing what happened in the past or point in time to what can happen and what they can control through better simulations and optimizations.

5) Source: <https://www.gartner.com/en/newsroom/press-releases/2018-09-12-gartner-hype-cycle-for-ict-in-india-ranks-machine-learning-among-three-technologies-to-have-a-transformational-business-impact-within-two-to-five-years>

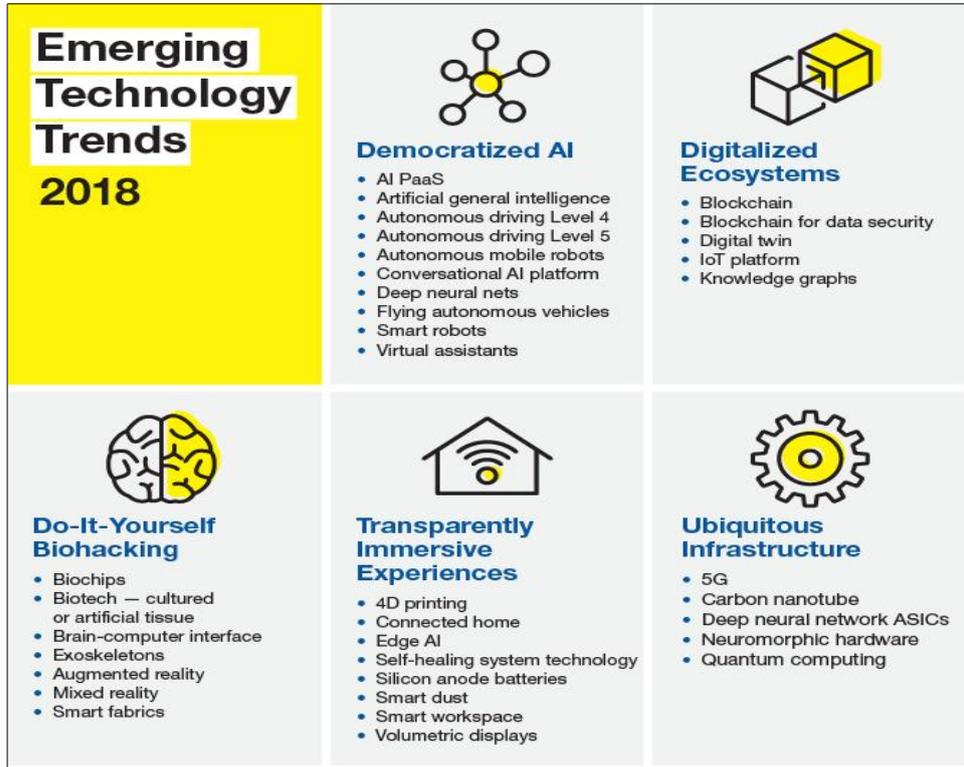
Figure 5. Hype Cycle for emerging technologies, 2018⁶⁾



Gartner (2018) mentions the following technologies which must be watched for (Figure 6):

- **Digital Platforms** - 5G, Digital Twin, Edge Computing, Blockchain, IoT Platform, Neuromorphic Hardware, Quantum Computing, Serverless PaaS and Software-Defined Security
- **Artificial Intelligence** - Deep Learning, Artificial General Intelligence, Autonomous Vehicles, Cognitive Computing, Commercial UAVs (Drones), Conversational User Interfaces, Enterprise Taxonomy and Ontology Management, Machine Learning
- **Immersive Experiences** - 4D Printing, Augmented Reality, Brain-Computer Interface, Connected Home, Virtual Reality and Volumetric Displays.

6) Source: <https://www.gartner.com/smarterwithgartner/5-trends-emerge-in-gartner-hype-cycle-for-emerging-technologies-2018/>

Figure 6. Gartner emerging technology trends 2018⁷⁾

In these technologies, Indian organizations are still taking a very cautious and risk averse approach as the understanding of these technologies is limited and they still want to take time to do pilot case studies. Large organizations which are very cash rich are putting small investments in the areas of machine learning such as large-scale recommendation engines and customer behavioral modelling. Typically, as expected banking and capital markets companies are on the fore front of this. Technologically laggard sectors like water utilities are also jumping on the bandwagon slowly. ICT has also thrown existential challenges to organizations and individuals. A very concerning example of this is privacy and security. The digitization of data, the expanding use of high-speed internet over personal computing as enterprise resources and the growing highly connected planet-wide networks have led to newer types of crimes. Global reach of technologies has allowed rouge actors to devise electronically enabled scamming schemes or hacking to gain access to systems to steal money (e. g. recent Cosmos bank hacking⁸⁾), intellectual property or private information or to disrupt systems that control critical infrastructure. ICT must tackle such challenges as they can undermine Indian public's trust in ICT systems, regulations and policies as well as government agencies implementing them.

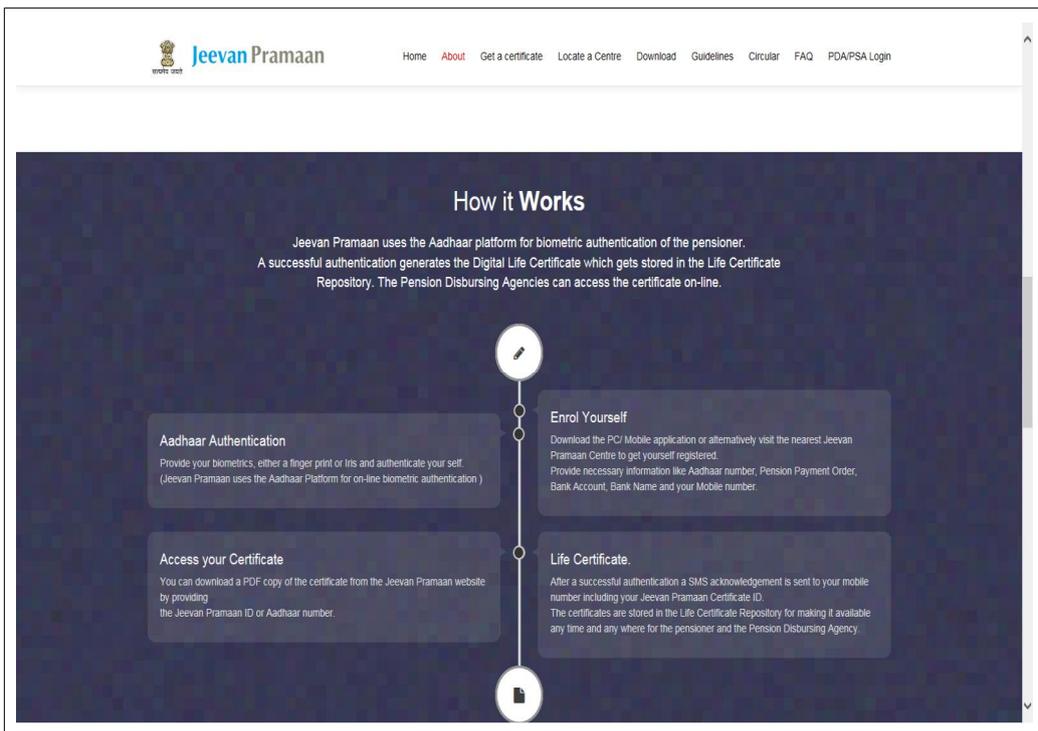
ICT has also brought automation and robots that displace workers who are unable to transfer their skills to new positions. ICT has allowed more and more people to limit their interactions with others, creating what some

7) Article: <https://www.gartner.com/smarterwithgartner/5-trends-emerge-in-gartner-hype-cycle-for-emerging-technologies-2018/>

8) Source: Economic Times <https://economictimes.indiatimes.com/industry/banking/finance/banking/cosmos-banks-server-hacked-rs-94-crore-siphoned-off-in-2-days/articleshow/65399477.cms>

people fear is a population that could lose some of what makes it human. Such non-technological aspects must also be considered as manual labor is still a large part of India's workforce. Rising automation will cut jobs in some areas but will bring newer types of jobs for skilled people. There is a need for serious retraining. Senior and aging population in India could be biggest beneficiaries of the ICT boom in India at the same time making their lives easier (example *Aadhaar* based digital living certificate generation⁹⁾ from the comfort of home without need of going to the bank to show a person is alive and thus making them eligible for pension). This application is shown in Figure 7. *Jeevan Pramaan* is a biometric enabled digital service for pensioners. This initiative strives for digitizing the whole process of securing the life certificate and streamlines the process of getting life certificate and making it hassle free and much easier for pensioners (especially super senior citizens older than 80 years of age). With this initiative, the pensioners requirement to be physically present himself/herself in front of the disbursing and certifying agency will become a thing of the past. It benefits pensioners in a huge way and cutting down on unnecessary logistical hurdles.

Figure 7. Online digital life certificate



4. Way forward for India

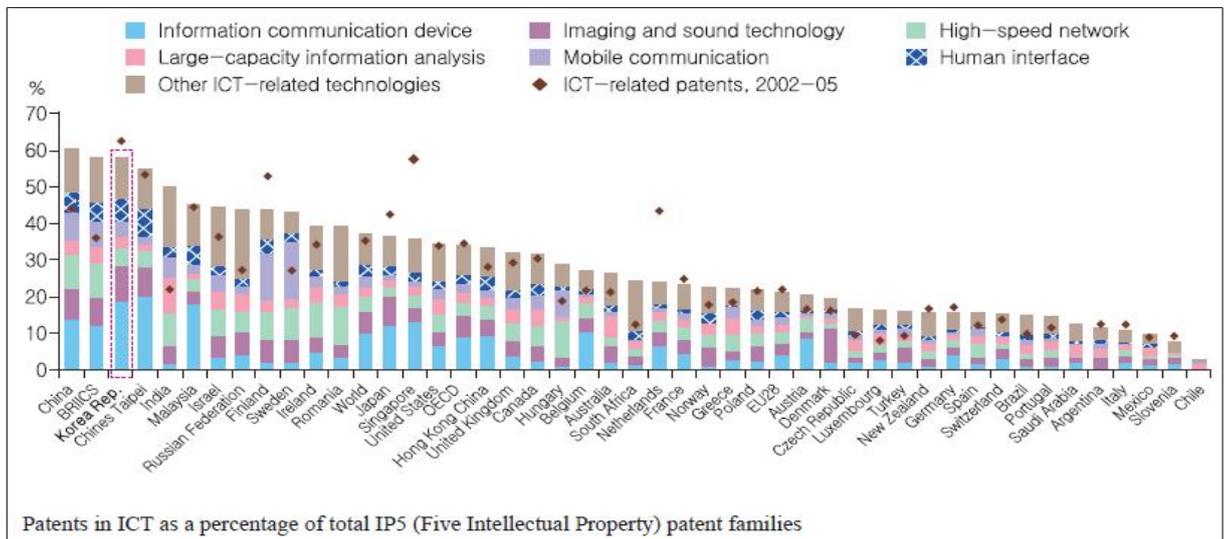
ICT sector has played a very critical part in India's economic might rise specially since year 1991. It has directly impacted citizens too in a positive way such that they have more information at their fingertips and can

9) Source: <https://jeevanpramaan.gov.in/>

take more informed decisions. Government of India’s newer initiatives such as “Make in India”, “Digital India” and “Startup India” have helped boost domestic manufacturing, innovative startups (Cisco, 2019). Such newer policies and removal of license *raj* have helped India propel by 30 places in the World Bank’s ease of doing business. However major initiatives need to be undertaken which are primarily in the areas of adoption of stringent intellectual property laws, international standards, predictability of regulations (e. g. a concerning case of retroactive taxation of Vodafone case for Vodafone’s acquisitions outside India on which the arbitration panel is contemplating), transparency at all levels, digitally skilled workforce, market regulatory aspects, uneven policy implementation and enforcement, investment friendly federal and local regulations. Regulatory hurdles are still a cause for concern. For the Vodafone case, the new government is signaling business friendly overtures¹⁰.

In a number of cases, all expectations and responsibilities are placed on bureaucracy, which should be a shared responsibility by private stakeholders, societal and industry stakeholders. Multinationals doing work in India are also looking for more transparent processes and policies and protection of intellectual properties. One new such area emerging is local storage of critical payments and consumer data in India itself in the lines of General Data Protection Regulation (GDPR). The GDPR like regulations require strong federal, state enforcement mechanisms and machinery as in developing countries, co-regulatory approaches may not be very effective. One area where India does well currently is specialization in ICT related patents – 66,738 patents in 2016 and growing each year (Figure 8). Also, India is home to one unicorn (US \$1 billion valuation), which is a company called Flipkart.

Figure 8. % of ICT patents to other technology patents¹¹⁾



ICT has evolved significantly in the Indian scenario and has been able to influence various societal and business aspects as discussed earlier. Ease of doing business is a key area which is directly influenced by ICT strategies, policies and implementation. Indian regulations sometimes require mandatory registration which

10) Source: <https://www.financialexpress.com/industry/vodafone-retrospective-tax-decision-was-erroneous-fm-arun-jaitley/1078063/>

11) 2018 ICT industry outlook of Korea by Korea Information Society Development Institute report: https://www.kisdi.re.kr/kisdi/upload/attach/Outlook_2018.pdf

causes delays and procedural delays for Indian organizations and startups. Of late, Indian government agencies have been more transparent and willing to talk to industry and business stakeholders. They are also keen to amend the policies for betterment of business improvement. Industry and business stakeholders are also ready to be more participative and are coming out with inclusionary plans. One of the key areas of discussions should be how ICT can enhance key government areas such as “Make in India”, “Digital India” by avoiding digital colonization and instead marching towards digital globalization except for areas related to National/Homeland Security. Make in India should also boost moving manufacturing in India and help significantly in the import substitution and local manufacturing/sourcing initiatives by adding to foreign exchange reserves kitty.

Other important aspects of ICT impact are in the areas of bringing digital parity between urban and rural population especially with respect to areas such as lifestyle, accessibility to latest information, education via virtual means, improving employability and reducing ecological impacts. Similarly, ICT has become a great leveler between the urban rich and rural poor in terms of various service availabilities, speed of access, technological awareness, self-directed learning opportunities, career networking opportunities, gaining skills, empowerment, etc. Such gap also used to exist in the western and eastern (especially north eastern) states of India which is also narrowing down due to increased usage of ICT.

4.1 Suggested actions for India

Based on the literature (references are mentioned at the end) and decades of information technology sector and academic experience of the authors, we propose the following actions for policymakers.

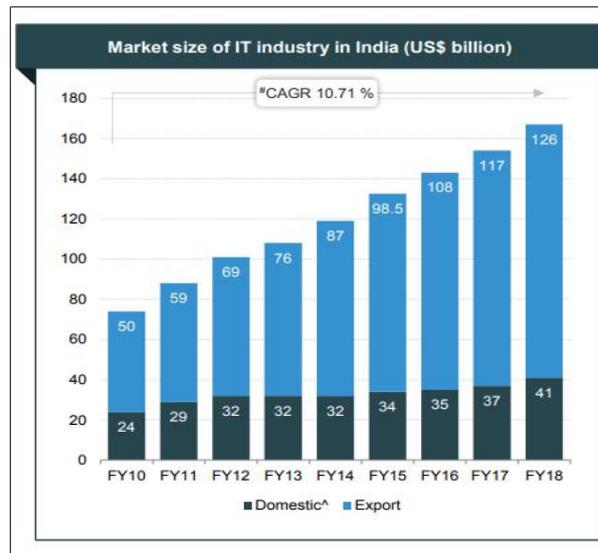
- 4.1.1 Creating a talent pool** – India is blessed with immense talent pool of youngsters which is the largest in the world. They can be agents of change for the ever-growing ICT wave. This pool makes India a strategic location for high tech and electronics companies for manufacturing hardware/circuits and launching in India. India is now becoming a global hub for VLSI/ASIC design. India has large setup base of engineering and technical universities and colleges. One government led initiative example is the Kerala State Development and Innovation Strategic Council (K-DISC¹²) launched an initiative – the Accelerated Blockchain Competency Development (ABCD). The main aim of ABCD is to impart training in blockchain technology to students and technology professionals, giving them the ‘early bird’ advantage adapting to the technology wave at the earliest. Indian fresher IT pool is estimated to be around 780,000 yearly as per India Brand Equity Foundation (IBEF¹³) report. Large consumers of fresher IT pool are IT enabled services (ITES), IT service companies, IT related manufacturing industries (electronics, etc.) and captive or global in-house centers.
- 4.1.2 Retaining and retraining the talent pool** – In India, ICT accounts for ~67% of services sector exports. To give an example, currently about 2.8 million people are directly employed in the ICT sector and around 7 million people are indirectly employed in the Telecom side of ICT alone. Indian organizations need to integrate the cross and up skilling efforts in the technical as well as sectoral areas. The skilling exercises also need to be tied up closely with dynamic market conditions by working closely with the industry and industry organizations. For people on the lower strata of the education, trades such as mobile repairs, cable and broadband internet technicians, digital marketing can generate significant self-employment. This skilled manpower can help people themselves in getting better opportunities and generate additional opportunities for them in MNCs operating in India. For people

12) Source: Technopolis <http://www.technopolisweb.com/2018/06/06/3713/>

13) Source: <https://www.ibef.org/download/IT-ITeS-Report-July-2018.pdf>

who have advanced degrees, government is already promoting investments and manufacturing in India through Make in India initiative. Indian IT + Business Process Management (BPM) market is supposed to reach US\$350 billion by 2025 (Figure 9). Overall IT + ITES + BPM + Software product engineering services are supposed to reach CAGR of 12.26%. Significant chunk of IT exports (57%) is IT services which will need huge talent base creation and continuous upskilling and cross-skilling. Current IT hiring is estimated to be approximately 200,000¹⁴⁾ in 2018 but India need 8 million jobs to be created per year to sustain growth and reduce under/un-employment.

Figure 9. India's IT market size¹⁵⁾



- 4.1.3 Impact on hiring sector in India:** As there is focus on automating basic services like maintenance, infrastructure, and moving them to the cloud, which is also increasing demand for new skills such as cloud, artificial intelligence, machine learning and robotics. AI could add US \$957 billion to the Indian economy by changing the nature of work to create better outcomes for businesses and society (Rewire for Growth). The sector is witnessing a surge in demand for niche skills in areas such as cybersecurity, information security, risk and digital technology. There are 10,000 - 15,000 open jobs related to cybersecurity itself across tech and non-tech roles, according to data from Teamlease Services.¹⁶⁾ Within the technology sector the demand is spread between ITES (25%), software products (non-security) or shared services or captives (24%) and security companies (9%). The bulk of the demand is from Delhi, Mumbai, Bengaluru, Hyderabad and Pune cities in India, as per the data.
- 4.1.4 Multiple agencies dealing with ICT:** In India, following agencies deal with ICT policies, strategies, enforcement, implementation and measurement.

14) Source: SHRM <https://www.shrm.org/shrm-india/pages/indian-job-landscape-to-improve-in-2018.aspx>

15) Source: www.ibef.org

16) Source: www.teamlease.com

- Ministry of communications
- Regulatory and appellate bodies such as Telecom Regulatory Authority of India (TRAI), Telecom Dispute Settlement and Appellate Tribunal (TDSAT)
- Central Statistical Office and National Sample Survey Office
- Ministry of Human Resources Development (HRD)
- Ministry of Electronics and Information Technology (MEITY)
- Ministry of Commerce (MOC)
- Ministry of Defense (MOD)
- National Standards Bodies such as ISO India, QCI
- *NITI Aayog* (planning commission)
- Department of Industrial Policy and Promotion (DIPP)
- Other semi-government agencies

These agencies need to come together to form a joint task force which will work on centralization of systems, unified surveying mechanisms, core group on futuristic technologies. These agencies will also need to work with multilateral and world bodies such as World Trade Organization (WTO), Global Alliance for ICT and development of United Nations (GAID), United Nations Economic and Social Commission for Asia and the Pacific - Asia Pacific Centre for ICT (APCICT), United Nations Educational, Scientific and Cultural Organization (UNESCO), Commonwealth Connects Programme (CCP) and G20 countries forum.

4.2 How Indian businesses are getting on the ICT bandwagon?

Businesses worldwide are sitting on wealth of data. They are slowly moving from being data wasters to data crunchers to data product creators (data monetization enablers). In last two years, so much data has been generated that it is more than data generated in the world by electronic devices before last two years. Technological advances fueled by big data in areas such as artificial intelligence, augmented intelligence, virtual reality, machine learning, deep learning are growing day by day. Indian businesses in areas of government services, telecom companies, banking, capital markets, insurance, retails, consumer products have widely adopted big data and ICT. Adaptability to change, innovation, enabling growth, customer intimacy, cost and license rationalization are major driving factors. The Indian government has set a target of making India US \$5 trillion economy by 2026. Indian businesses will enable this quantum jump by creating new business models, leveraging new technologies to fuel jobs and growth of Indian jobs. In next three years, Indian ICT sector's revenue is supposed to touch US \$225 billion with a CAGR of approximately 11% YoY. To elaborate a very good example of what could be a big collaboration between Indian businesses and governmental organizations is upcoming digital push for Indian Railways. Indian Railways are planning bar coded tickets, GPS based information systems in the coaches, integration of IT systems in all aspects of the Indian Railways and potential foundational work for the upcoming bullet train project between Indian cities of Mumbai and Ahmedabad. Indian Railways Tourism and Catering Corporation (IRCTC) moved from booking 29 tickets online to 1.3 million tickets per day with the help of in memory data grid application.

Other big area witnessing spurt in ICT spending is healthcare where multiple applications abound. To name a few – a) teleradiology, b) digital pain less screening X-Rays and scans, c) mobile applications for qualified medical/emergency staff including automation assisted triaging, d) electronic medical records, e) robotic surgeries, f) AI assisted disease diagnostics, g) clinical trials, h) health information systems, i) digital consultation, j) precision medicine, k) virtual assistants and chatbots. etc. Forbes magazine cites one study¹⁷⁾

17) Source: <https://hbr.org/2018/05/10-promising-ai-applications-in-health-care>

which involved 379 orthopedic patients found that AI-assisted robotic procedure resulted in five times less complications compared to surgeons operating alone without robotic assistants.

5. Epilogue

Government, citizens and industry need to engage in a participative and consultative, collaborative approach which encourages innovation and promotes healthy competition with minimum government interference. India must take bold steps to achieve societal and inclusivity benefits of ICT such as better education, better healthcare access and prediction of treatments, reduction in child mortality, environmental issues, to name a few. India's prime minister Mr. Narendra Modi has given a philosophy for all – “Sab ka saath sab ka vikaas” which means development for all with involvement of all the people of India. This is a key strategic philosophy which is guiding all the government departments and agencies. This approach has resulted in growing India's broadband consumer base to 325 million in 2017, and data consumption to 5.6 million terabytes. Now 600,000 strong rural governing bodies (gram panchayats) are now connected by broadband connectivity. Government stakeholders mentioned above need to create conducive environments, foster research and development, coordinate in technical and policy issues and initiate important projects and help foster ICT and ITES related exports to further ICT growth in India.

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