CSD Working Paper Series: Towards a New Indian Model of Information and Communications Technology-Led Growth and Development

National ICT-Driven Development Policy
Comparing Approaches in India and China

ICT India Working Paper #2

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Executive Summary

Prior to 1991, India was mired in economic stagnation related to a bloated public sector, opaque business regulations and an inefficient industrialization policy based on import substitution. To avert an incipient foreign exchange crisis, the government introduced a raft of liberal reforms including reduced import taxes, market deregulation, and incentives for foreign investment. These reforms have largely been responsible for the consistently high GDP growth India has experienced since 1991, driven by entry of foreign capital and advancements in the services sector. However, the wealthy have been the greatest beneficiaries of this growth, as earnings inequality between the top and bottom 10% of the population doubled between 1991 and 2013.

ICT has been the largest enabler of this rapid growth by making India's comparative advantage in the service sector accessible to the global economy. India has grown into a giant in the global services outsourcing industry, and concurrent increases in digital talent have propelled India's information technology industry into becoming a major player both domestically and abroad.

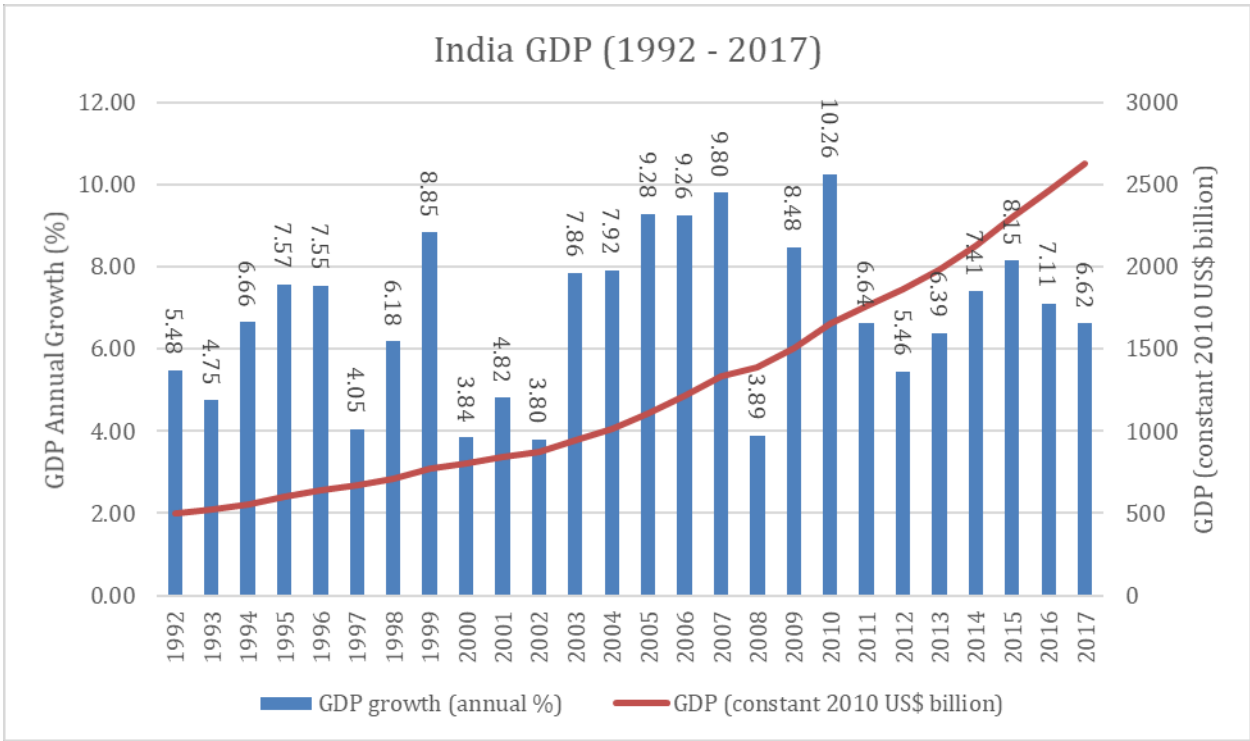
China experienced a similar trajectory, as economic opening and reform over the period from 1978 to 1989 was followed by ambitious government promotion of specific cities as global manufacturing hubs. Low labor costs and business-friendly policies within Special Economic Zones (SEZs) attracted initial foreign investments, snowballing as the region developed into a manufacturing hub. As skill in the manufacturing sector increased, particularly in the hardware and electronics industries, China has risen up the value chain to develop increasingly complex components indigenously. National economic planners now prioritize high-tech manufacturing, and the rise of China's gigantic tech companies has powered a simultaneous rise in the country's service industry. Incipient public investments are now targeting development and applications of Artificial Intelligence, which stands both to further elevate the manufacturing sector and place China at the center of future global economic developments.

ICT, as a set of tools that can integrate users into the national economy while democratizing service delivery, provides an excellent toolkit to promote the inclusive growth that liberalization has not yet delivered in either economy. To do so, however, national policies to encourage ICT-led growth and development must be put in place. While China has largely made successful infrastructure investments to encourage digitization across the country, India continues to lag in certain key measures. In contrast, while India has introduced specific strategies to leverage AI as an engine of inclusive growth, China's AI development strategy prioritizes achieving a dominant position in the global market over using AI domestically as an engine of broad-based development.

Moving forward, India should draw lessons from China's success in implementing strategic federal initiatives and developing local capacity to expand the public sector's capacity to support ICT-driven development. In addition, India should recognize the need to develop enhanced research capacity as ICT, especially AI, makes increasingly essential contributions to the economy. For its part, China should make targeted investments in ICT-driven development for sectors likely to lag behind. It should also clarify the tension between its competing priorities of maintaining stability and encouraging innovation.

Economic Background

Trends in India



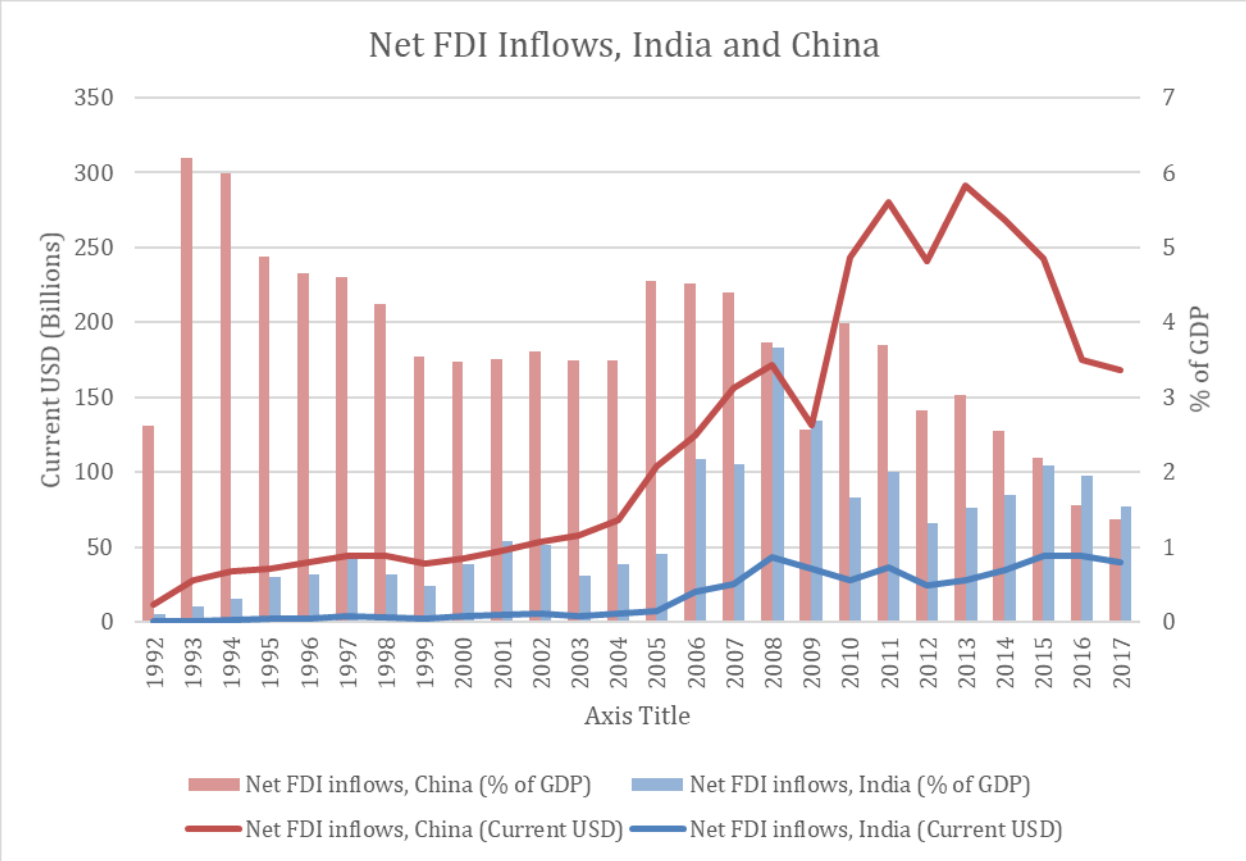
After economic reforms in the early 1990s, India has consistently seen moderately high levels of growth, never dropping below 3.8% per year. Additional reforms could push annual growth as high as 10% on a regular basis. However, ensuring inclusive growth remains a concern.

In 1991, India found itself in an economic crisis. A longstanding policy of import substitution industrialization, combined with a large, persistently growing public sector and complicated business regulations which conspired to depress private domestic and foreign investment, had led to high levels of combined trade and fiscal deficit. As falling exports forced the country to rely on foreign reserves to meet international debt obligations, the Reserve Bank of India's reluctance to permit devaluation of the Rupee caused the country's foreign exchange reserves to rapidly deplete, to the point where India could only finance three weeks of essential imports.

Following emergency measures to avert the crisis, the Indian Government introduced a program of liberalization that included reduced import taxes, market deregulation, increased incentives for foreign investment, and lower taxes. These reforms have been seen as largely responsible for India's high growth rates since 1991. After reaching a low of 1.06% in 1991, GDP growth has not since dropped below 4%, averaging nearly 7% and reaching a high of 10.3% in 2010 (World Bank). Former RBI Governor Raghuram Rajan has argued that with

additional reforms, particularly regarding land acquisition, India could reach 10% annual growth.[1]

Foreign capital has played a vital role in this growth, as looser regulation made India a more inviting environment not only for international businesses to expand their Asian footprint, but to also set up more permanent, domestic divisions. With English as one of its two official languages, and high numbers of graduates in STEM sectors, India has become recognized for its comparative advantage in service provision, particularly in the telecommunications sector. Outsourcing alone has become a $150 billion industry with growth projected at 10% in 2016-17.[2] The sector now employs 3.5 million people and represents 9.5% of India's GDP. With anticipated crackdowns on the International Entrepreneur and H-1B visa programs in the United States, Indian outsourcers may experience an influx of highly educated talent that otherwise would have emigrated, and may have an opportunity to provide higher value-added services.[3]



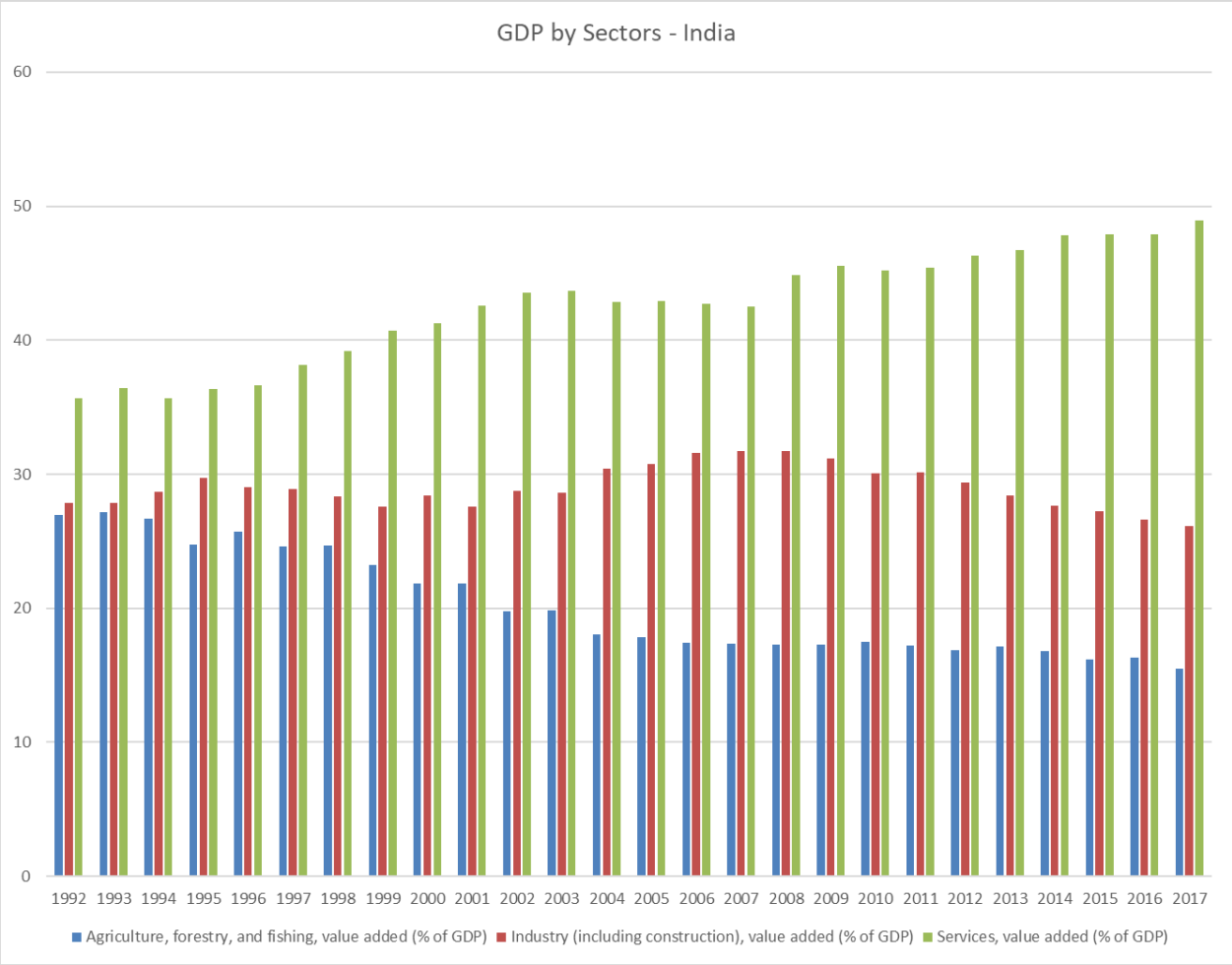
China's growth was initially driven by high levels of foreign direct investment, but FDI has fallen as a share of overall GDP as domestic firms have gained traction and GDP has increased. FDI in India has risen both in raw terms and as a share of GDP as India increasingly becomes a global services hub.

[1] https://www.cnbc.com/2018/03/19/indias-economy-needs-to-grow-10-percent-former-imf-chief-economist.html

[2] https://economictimes.indiatimes.com/tech/ites/indias-technology-vendors-paddling-shaky-boats/articleshow/56543653.cms

[3] https://qz.com/india/1279732/h-1b-visa-rejects-return-to-india-leaving-their-american-dreams-behind/

However, economic liberalization has not yielded inclusive growth. What growth has occurred has largely resulted from increased consumption by the wealthy, with earnings inequality between the top and bottom 10% doubling between 1991 and 2013.[4] India's top 1% now hold a greater share of national wealth than anywhere else besides Russia, standing at 58.4% as of November 2016. According to an OECD survey, better delivery of infrastructure, education, and basic services, particularly in rural areas, would lead to reduced poverty and greater creation of employment.[5] ICT provides a superb toolkit for doing this in such a way that it both reaches far-flung populations and helps integrate them into the future of India's service-driven economy. Digitally-enabled tools can not only allow new groups of people to participate in the formal economy and take part in the benefits therein, they can enable service delivery and verification for groups never reached before.



Services have taken over the dominant role in the Indian economy as agriculture, once the economy's backbone, has declined in importance. Manufacturing experienced a surge in the mid-2000s, but since then, India's comparative advantage in services has caused this sector to reassert itself. Besides, manufacturing has not taken off in India, as it did in China in the 1980s and the 90s due to lack of reforms in the areas of labor laws; land laws; exit policy; small-scale industry product reservation; unavailability of the required physical infrastructure and significantly underperforming SEZs.

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

[5] https://web.archive.org/web/20110606112149/http://www.oecd.org/dataoecd/17/52/39452196.pdf

Trends in China

The People's Republic of China was founded following over 20 years of fierce civil war in 1949, two years after India gained its independence. In the following four decades, both countries followed almost identical growth trajectories, with GDP (PPP) per capita standing at roughly 1200 USD in both countries as late as 1992. Since then, however, China has experienced rapid exponential growth that India has not matched. The story of this growth relates to judicious policy reforms creating an opening for growth, fortuitous timing allowing China to find a dominant niche in the global economy, and forward-looking governance offering future opportunities for economic development.

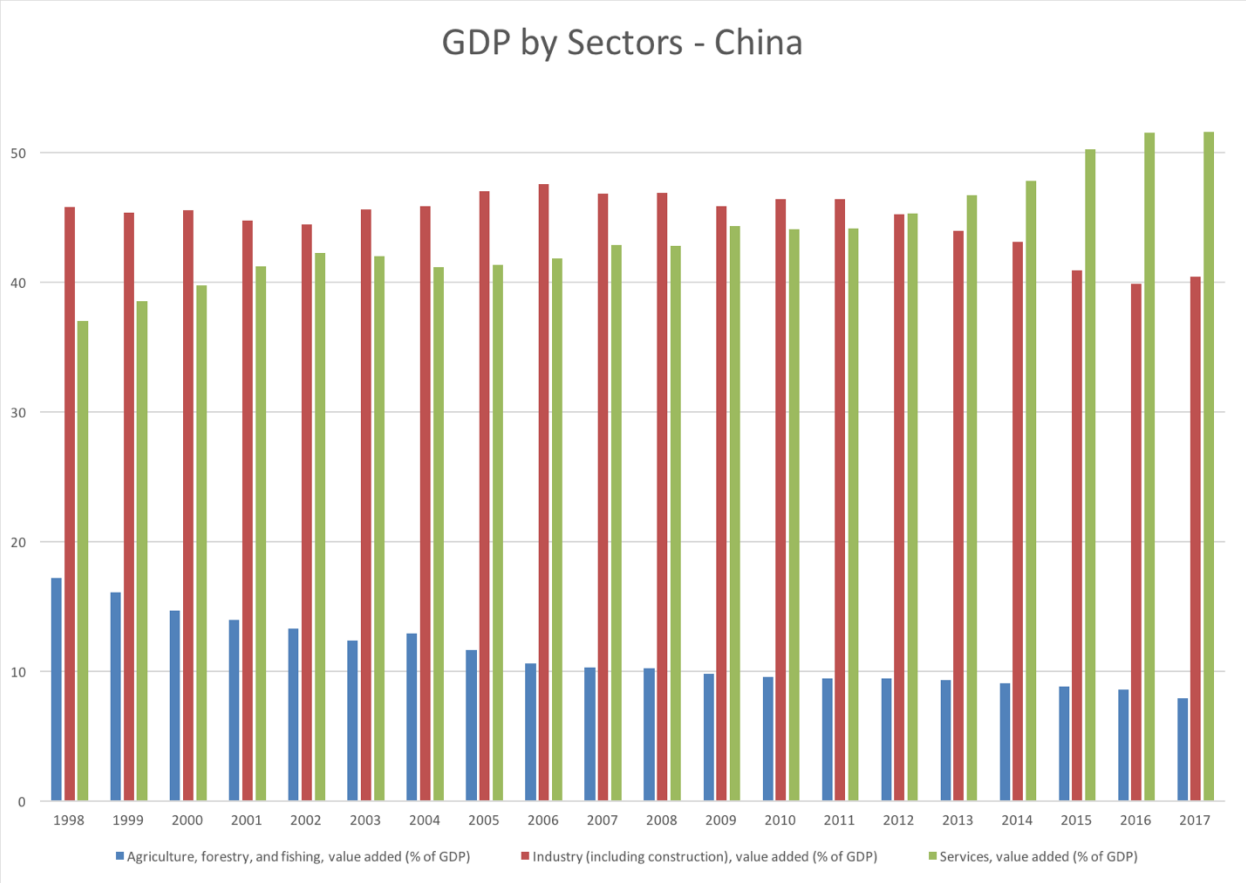
The foundations of the modern Chinese economy were laid following the death of Mao Zedong under the chairmanship of Deng Xiaoping from 1978 to 1989. Under Deng, China's first Special Economic Zones (SEZs) were introduced, with the small fishing village of Shenzhen as the flagship. These SEZs created space for Chinese companies to experiment with market capitalism and international trade under the auspices of reduced taxes and tariffs, looser regulations, and depreciation of the RMB. As a result, domestic companies rapidly expanded their production capacity in consumer electronics, and as supply exceeded demand, began to explore overseas markets. This has enormous growth implications for the cities at the vanguard of this movement - Shenzhen, for example, grew at an average rate of 40% between 1981 and 1993.

Opening and reform drove exponential growth in the Chinese economy, peaking in a boom decade from 2002-2011 during which growth never fell below 9%. With China having solidified its middle-income status, growth has since slowed as the country prepares for a transition from extensive to intensive growth, from adoption to innovation, and from a manufacturing-driven to a services-driven economy.

SEZs like Shenzhen also sparked the development of industrial clusters that served as proofs of concept for potential foreign investors. After Deng's "Southern Tour" in 1992, in which he advocated for entrepreneurship and open economic policies throughout the Pearl River Delta and Shanghai, FDI truly took off. Electronics led the way, with 60-70% of foreign investment in this sector, and as new technology was shared, product quality improved and higher-value Chinese exports became more internationally competitive.

China today has become a manufacturing superpower. With the transition from a rigorously planned economy into a looser system of state-driven capitalism, rapid increases in foreign investment have allowed China to use its low cost of labor to create a strong comparative advantage in the sector. As a result, China's economy has grown at an average rate of 9.12% over the past two decades, with industry and manufacturing contributing the greatest value added to GDP through 2012. The "world's factory" continues to revolve around its SEZs, which continue to be centers of FDI, new ventures and export processing. Modern Shenzhen alone has grown into a city of 13 million.

Since 2012, increased economic development and a more educated populace has caused China's economy to start undergoing a new transition. While these developments have caused China's comparative advantage in manufacturing to decrease, the service sector's contribution to GDP has experienced steady increases. The development of the Chinese service sector has largely been led by advancements in the ICT sector, as a growing domestic market and protectionist policies have allowed Chinese internet companies to rapidly grow into some of the largest in the world. As of 2018, Tencent, Alibaba, and Baidu have attained market caps of 580 billion, 542 billion, and 99 billion USD, good for 3rd, 5th, and 8th in the world. These companies have reached these milestones despite catering almost exclusively to a domestic customer base. With the Chinese government frequently requiring technology transfer and joint ventures with domestic firms as a prerequisite for foreign companies wishing to enter the vast Chinese market, the knowledge transfer driving this transition seem set to continue as long as these companies continue doing business in China.



Prior to 2012, manufacturing represented the largest slice of China's GDP. This was followed closely by services, many of which were engaged in supporting the manufacturing sector. Since 2012, with the rise of China's large technology and internet companies, services have taken over the top spot in place of manufacturing.

ICT and Sectoral Specialization

Software and services in India

The service sector does not simply represent the largest section of the Indian economy. It also comprises the fastest growing services sector in the world and accounts for 28% of all employment in the country.[6] The source of this growth has been India's innate comparative advantage as a global services provider, thanks to the English language, low costs of labor, and a market feedback mechanism that successfully encouraged graduates to specialize in industries where the rise of global communications technology would provide them opportunities for future work.

India first emerged as a hub for outsourcing in the early 1990s, during which the air travel and IT industries realized that rapidly decreasing costs of communication meant they could not only send much of their back-office work to be completed abroad at lower expense, but also that India's geographical location would also allow much of this work to be completed while main offices were closed for business, improving business efficiency. Since this early

[6] https://www.ciiblog.in/indian-services-sector-multi-trillion-dollar-opportunity-for-global-symbiotic-growth/

stage, industrial clustering has eventually allowed India to emerge as a global hub for software and IT services (Bajpai et.al., 2004)[7]. Today, India is responsible for 55% of the 190 billion USD global services sourcing industry, while maintaining 60-70% cost savings on average over source countries.[8] This competitive cost advantage is expected to increase as the rupee weakens, freeing up more cash for these companies to undertake more innovative research.[9]

In recent years, India has also succeeded in moving up the value chain of IT-enabled Services (IteS). With 75% of global digital talent, India has grown into a source of digital innovation and a wellspring of intellectual capital itself, and several international IT firms have decided to place their own innovation centers in India. The 167 billion information technology industry in India has increasingly looked for domestic business opportunities as information technology plays a greater role in the lives of Indians, and spending on IT within India is expected to have grown 9% through 2018 to reach 87.1 billion USD. Through 2019, the IT sector is expected to continue growing at a 7-9% rate, albeit with close to neutral job creation as technology jobs migrate to non-technology focused companies.[10]

While FDI slumped in 2017-2018 as the result of interest rate hikes by the United States Federal Reserve, FDI overall has trended upwards as India's comparative strengths continue to attract foreign companies.[11] As leading companies such as Infosys, Wipro, and Tech Mahindra develop indigenous blockchain and artificial intelligence solutions to solve clients' problems, NASSCOM, India's IT-BPM trade association, has launched an online platform intended to up-skill two million professionals and an additional two million students. Alongside this private investment in sustaining India's human capital advantage in the services sector, the government has also announced initiatives to champion the IT sector, introducing a strategic plan to transform India not just into a hub for ICT services, but also into a hub for artificial intelligence research, implementation of AI solutions to societal problems, and an exporter of AI-enabled services tested at scale to other developing countries.

Hardware and smart manufacturing development in China

Electronics manufacturing has made up a core component of China's economic development strategy since the Reform and Opening period. Since then, national economic planners have increasingly promoted entry into high-tech manufacturing and the development of a long-term ICT manufacturing and development strategy. However, despite China's modern position as a major exporter of consumer electronics, the country's role in electronics manufacturing has historically been limited to assembling completed components. Even major manufacturers like Lenovo, the world's largest PC vendor and sixth largest hardware company, have traditionally relied on chips provided by foreign companies such as IBM.

China's first ICT development strategy was issued by the State Council in 1984. It indicated that the electronics manufacturing industry should focus on microelectronics, particularly

[7] https://academiccommons.columbia.edu/doi/10.7916/D8H1319M
[8] https://www.ibef.org/industry/information-technology-india.aspx
[9] https://foreignpolicy.com/2018/10/17/indias-sleeping-tech-giants-are-about-to-awaken/
[10] https://economictimes.indiatimes.com/tech/ites/indian-software-services-sector-to-grow-7-9-in-fy19-nasscom/articleshow/62995685.cms
[11] https://economictimes.indiatimes.com/markets/stocks/news/fdi-in-services-sector-slumps-23-in-2017-18/articleshow/64995433.cms

computers and communications equipment, and that services in the electronics and information sectors should focus on supporting cluster development for this industry. By 1997, China had developed its first strategy for "informatization," or integrating information technology into national economic development. The resulting "2010 Vision," as part of the Ninth Five-Year Plan, called for state-led unified standards in ICT, interconnection, and resource sharing. The Tenth Five-Year Plan, published 2001, built on this by proposing incorporating information technology into industrialization strategy. The National Development and Reform Commission (NRDC), China's chief macroeconomic planning agency, would introduce the first "Informatization special plan" later that year.

An information technology strategy was fully integrated into national economic planning by 2006, when the National Informatization Development Strategy was published. This document remains in force as China's active long-term ICT development strategic framework through 2020. Over this time period, China intends to become a leader in "smart manufacturing" through ICT integration into modern factories and even AI-assisted processes.

Following these policy initiatives, China has worked to scale up from simple assembly to indigenous hardware design and development. Chief among these initiatives is "Made in China 2025," which aims to transform China into an innovation-powered leader in technologies that will drive future economies such as AI. With regards to manufacturing, the plan encouraged the whole sector to produce higher value-added components and prestige goods domestically. Semiconductor manufacture was specifically named as a priority industry within the initiative, and between direct government funding, public-private partnerships, and university-led research, China's total investment into semiconductor manufacturing R&D currently stands at 140 billion USD according to Credit Suisse.[12]

Private hardware companies have advanced closer to the cutting edge of existing technology on the back of this R&D investment. In 2013, Lenovo greatly expanded its integrated circuit design team with an eye towards eventually substituting foreign processors with domestically manufactured ones, especially in the smartphone and tablet markets.[13] On the other end of the computing spectrum, Lenovo has applied newfound knowledge and its manufacturing advantage to emerge at the forefront of the liquid cooling market for data centers, which could position the company to build more powerful supercomputers than can currently be made available for mainstream customers.[14] As countries grow concerned about potential security concerns related to Chinese-sourced hardware,[15] possibly diminishing international trade in the sector, thorough vertical domestic integration of Chinese hardware manufacturing could prove critical for the sector's continued success.

Federal Policies and Initiatives to Promote ICT-led Growth and Development

[12] https://asia.nikkei.com/Spotlight/Cover-Story/China-s-upstart-chip-companies-aim-to-topple-Samsung-Intel-and-TSMC

[13] https://www.eetimes.com/document.asp?doc_id=1264663

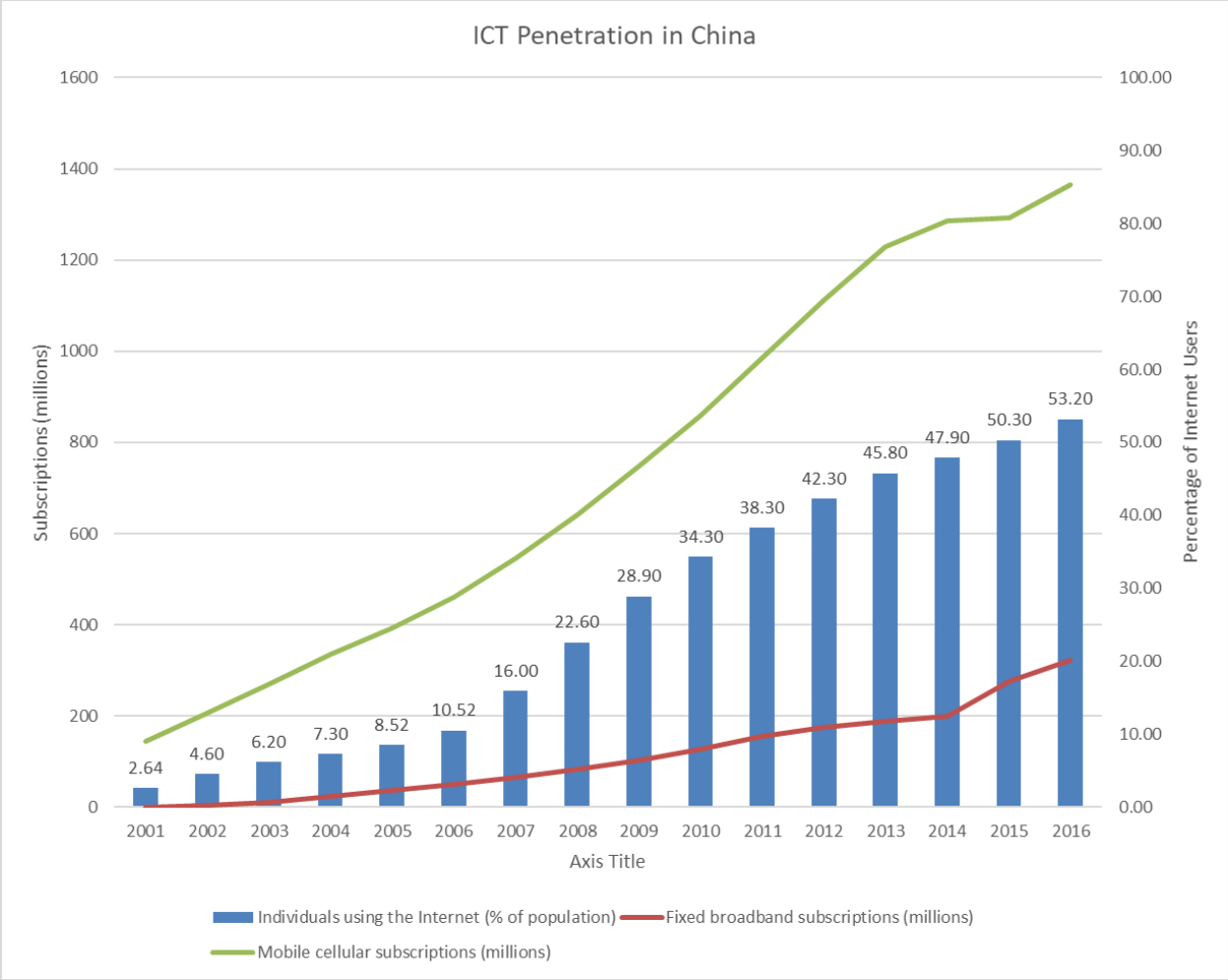
[14] https://www.datacenterknowledge.com/power-and-cooling/lenovo-aims-new-liquid-cooling-designs-mainstream-data-centers

[15] https://www.bloomberg.com/news/features/2018-10-04/the-big-hack-how-china-used-a-tiny-chip-to-infiltrate-america-s-top-companies

Infrastructure

An expansive and reliable infrastructure network is critical to the success of ICT-driven development. In order for mobile technology to effectively facilitate communication and the exchange of large quantities of information across large distances, customers must have access to high-speed data networks that offer consistent connection speeds even in remote areas. In a similar fashion, broadband internet connectivity is critical to the success of both commercial and non-commercial applications of ICT. More basic investments in infrastructure are required before modern ICT can even function properly. For example, applications of digital or communications technology intended to form the backbone of development interventions are not feasible in localities without sufficient or dependable access to electricity. While basic infrastructure is in place across India and China to promote the adoption of information and communications technology, the best way to measure the impact of these investments on ICT usage is to directly examine adoption of the targeted technologies.

China



In China, booming investments in multiple areas of infrastructure over the past two decades have been one of the primary engines of the country's exponential economic growth. These investments have both directly funded the expansion of communications infrastructure and have promoted the wealth generation that has encouraged a larger share of the Chinese population to adopt and benefit from ICT. The results have been astounding. In 2001, a mere 2.64% of the population regularly used the internet. Between 2006 and 2009, this rate nearly tripled from 10.52% to 28.90%, before almost doubling again to 53.20% by 2016, the most recent year with available data.

Mobile cellular subscriptions experienced a similar explosion. In 2001, China had under 150 million mobile subscriptions. With robust investment first in basic wireless networks, and then in GPRS-enabled mobile networks, mobile subscriptions rose to nearly 400 million in 2005, three quarters of a million in 2009, and one billion in 2011. 1.365 billion subscriptions were active in 2016, virtually equivalent to one for every man, woman and child in the country. China Mobile now hosts the world's most expansive LTE network, and China is

now leading the world in the race to introduce a nationwide 5G network, having outspent the US by 24 billion USD since 2015.[16]

Broadband internet has been the latest to benefit from the Chinese government's infrastructure investments. Chinese broadband subscriptions stood at just a third of a million in 2001, before increasing by over a hundred-fold to 37 million in 2005. Since then, subscriptions have again increased by almost ten-fold to 323 million in 2016, roughly a 12% growth rate. With continuing to "build up bases of modern information-intensive infrastructure" identified as a priority goal in the 13th 5-year plan of 2016, China's high levels of investment in ICT-related infrastructure seems set to continue.

Telecom sector reform in China

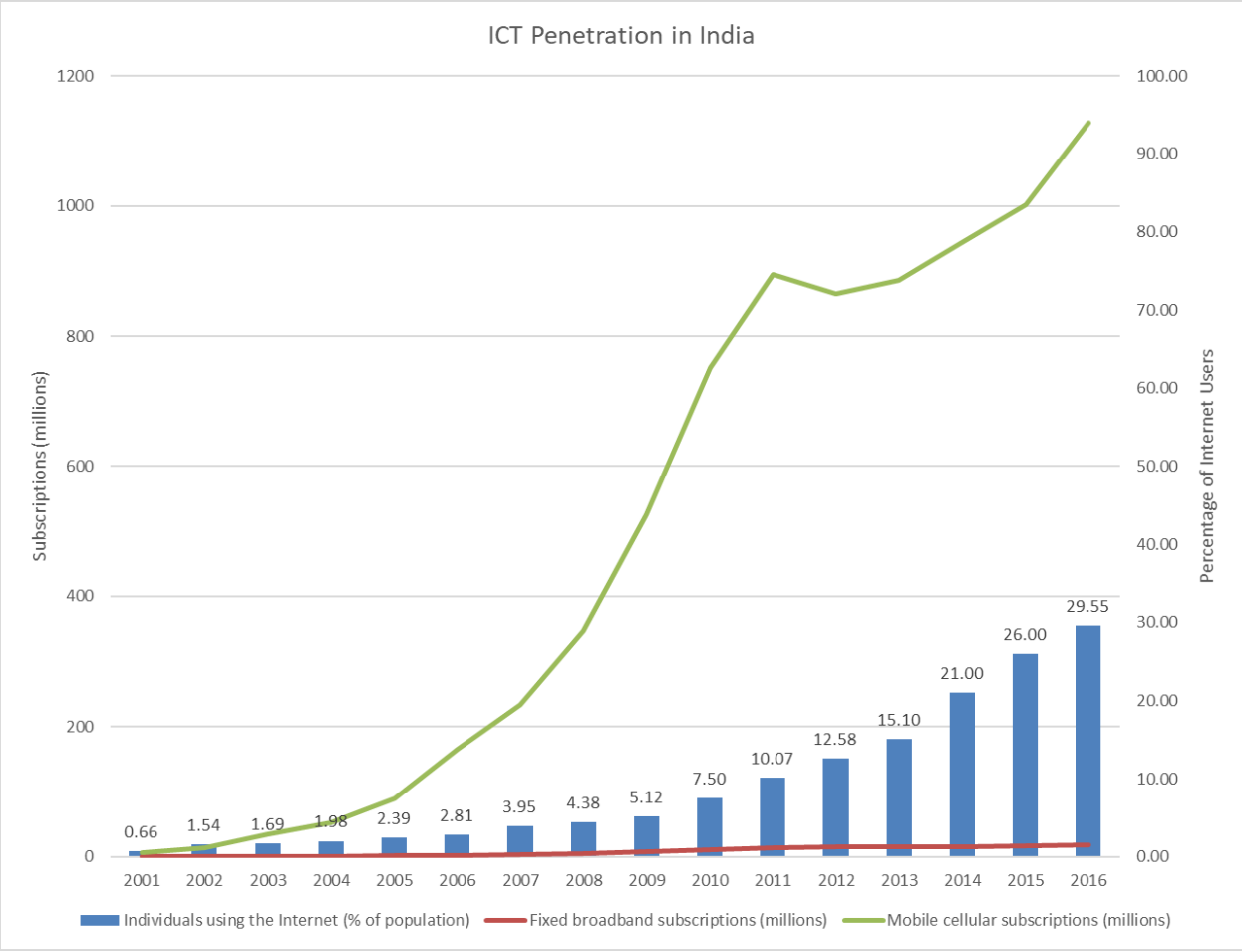
Much of this growth in usage is also attributable to a series of reforms in China's telecommunications sector. Until relatively recently, the Chinese telecommunications sector was the province of direct central government control, resulting in many of the same inefficiencies as those that had plagued the country's planned economy over the thirty years following the establishment of the PRC. However, reforms in the sector have not only made wireless communications cheaply and easily accessible for the general population, they have allowed cellular technology to become the backbone of China's newly emerging mobile economy.

Prior to 1980, telecommunications were under direct control of the Ministry of Posts and Telecommunications. Although prices under state control were fixed, this planned approach did not efficiently communicate service provision needs to the government, resulting in poor, scattered coverage across the country. The sector underwent reform through 1993, as prices were deregulated and management of telecom service was devolved to local government. Still, however, telecom service remained extremely rare and expensive. A cellular phone, for example, cost roughly 3000 USD before factoring in service charges.

In 1994, the China United Telecommunications Corporation was founded, breaking a duopoly in the telecommunications market that had stifled innovation and competition. Further institutional and industrial restructuring continued through 1998, as government withdrew from direct management of state-owned enterprises, more companies were incentivized to enter the market, and competition in the sector increased. By June 2001, seven licensed public telecom operators were on the market. The market has since stabilized and consolidated somewhat, with China Mobile, China Unicom, and China Telecom remaining as the country's three largest mobile providers.

[16] https://www2.deloitte.com/content/dam/Deloitte/us/Documents/technology-media-telecommunications/us-tmt-5g-deployment-imperative.pdf

India



India has not kept pace with China regarding adoption of information technology, but its rapid rate of cellular adoption has allowed the country to remain positioned for the upcoming digital revolution. The early adoption of mobile communications technology presaged the ongoing and widespread adoption of information technology by the general population. Internet usage has now entered a period of exponential growth, and while levels of broadband connectivity remain low, they have steadily risen over the past fifteen years.

In 2001, India had a mere 6.5 million mobile subscriptions. By 2006, though, India had reached 166 million subscriptions, slightly more than China had had five years prior. Annual subscription growth did not drop below 40% until 2011, and by 2015, subscriptions crossed the one billion mark. As of 2016, 1.13 billion mobile subscriptions were active in India, slightly less than one subscription per person in the country. Since 2016, new private initiatives have been introduced to make mobile data service affordable and accessible to even more than before. Chief among these is Mukesh Ambani's Reliance Jio service, a 20 billion USD investment promising to bring 4G service to 90% of the population for roughly 2 USD/month.

Making the internet reliably available over wireless networks will be key to accelerating India's lagging rate of internet adoption, due to the limited availability of fixed digital infrastructure attested to by the low number of fixed broadband subscriptions in the country. India did not reach one million broadband subscriptions until 2005, after having only 50,000

in 2001. By 2010, 10 million subscriptions were active, and 18.6 million subscribers were online in 2016. But despite steady year-on-year growth, the baseline of broadband infrastructure has been too low for this growth to make a meaningful dent in India's overall internet usage. More likely, these broadband subscribers are individuals in urban areas who are upgrading from their prior reliance on wireless networks rather than new users.

India still has a long way to go before the whole population is capable of reliably connecting to the internet and meaningfully participating in the new digital economy. Through the end of 2008, internet usage languished at under 5% of the population, before reaching 10% in 2011 and 20% in 2014. Internet usage stood at just under 30% in 2016, with mobile connections providing the vast majority of this access. Furthermore, these wireless networks have a reputation for slow and patchy access, especially in poor and underserved areas. According to Hutokshi Doctor, director of the Centre for Communication and Development Studies (CCDS), slum-dwellers "often have to trek down the hill [and] come down to the main road to access the network."[17] Finally, a substantial rural-urban divide exists in mobile phone ownership, with 71% urban penetration compared to 55% rural penetration in 2018.[18]

Artificial Intelligence

In the same way that electricity fueled the second Industrial Revolution, and the internet helped create the modern digitally-enabled economies we see today, artificial intelligence has the capacity to become the world's next general purpose technology (GPT). GPTs can be implemented to improve processes in virtually every sector, and so they are capable of revolutionizing virtually every sector. Prior GPTs made employees vastly more capable by augmenting their physical and mental capacity to complete work, either by taking over physical tasks or by making information for mental tasks more easily processed or accessible. AI stands apart from prior GPTs because it could eventually not just complement human labor, but substitute for it altogether. AI is already quite capable of performing and autonomously managing regular and predictable tasks such as warehousing, cataloguing, and assembly. As the technology evolves over the next decades, and AI increasingly takes over "human" tasks like logical reasoning, creativity in design, and business management, businesses and policymakers will need to adapt to a future of work in which some old jobs become obsolete, others have drastically redefined roles, and a crop of new jobs aimed at supporting AI analytics emerges. As early as 2022, 46% of the current workforce will be engaged in jobs that do not yet exist or have radically changed skillsets.

With dropping costs of computing power and data storage, using AI at broader scales has become significantly more viable in recent years. AI globally is anticipated to grow at a rate of 50.1% annually through 2021, reaching 57.6 billion USD. This explosive growth rate is further augmented by the increasing digitization of all types of data, which has made training data for AI models more readily available and taken advantage of.

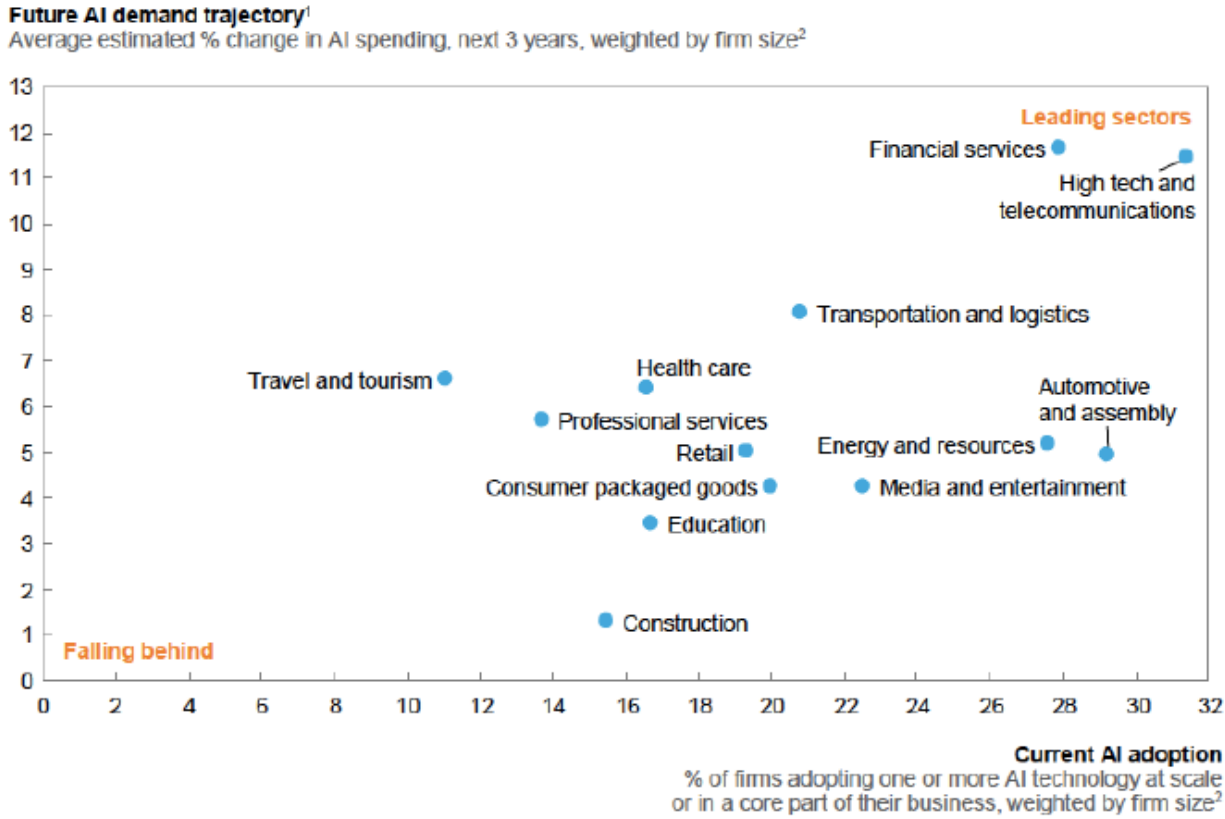
To prepare for this revolution, India and China have taken sharply different approaches toward implementing AI in their growth and development strategies. Among the strategies these countries have used to create beneficial ecosystems for AI development have been infrastructure improvements like "data trusts," connectivity infrastructure, and common computing facilities; fiscal incentives; and public-private coordination through technology parks, government facilitation, and "national teams" involving large private actors in

[17] https://money.cnn.com/2016/03/09/technology/india-internet-access/?iid=EL
[18] https://indianexpress.com/article/technology/tech-news-technology/internet-in-india-gaping-gender-gap-5296818/

fundamental and applied research. These varying approaches hold implications for their prosperity and global roles decades down the line.

India

Until this point, commercial implications have served as the greatest determinant for AI adoption by an industry. In India, manufacturing has led the way so far; according to a BCG study, India's manufacturing sector has the third highest AI implementation in the world, with 19% of companies already using AI to a significant extent, and a full 96% plan to adopt AI within the next three years.[19] Banking has also been a leading sector, with virtual customer assistance, chatbots, and robo-advisory clients as initial examples of AI implementation in the space. In contrast, healthcare, education, and agriculture, three of the sectors targeted in ICT-driven development, have fallen noticeably behind. Outside investment and private sector initiatives like that of the Robert Bosch Centre for Data Science and Artificial Intelligence (RBC-DSAI) have heightened this inequality between sectors by focusing funding on applied research in areas succeeding in AI adoption. Besides commercial viability, additional factors holding back some sectors while boosting others have included technical feasibility, structured data availability, regulatory barriers, privacy considerations, ethical issues, and preferences for human interaction.



"Business as Usual" trajectories for AI implementation in several global sectors. Adapted from National AI Strategy Discussion Paper.[20]

[19] https://www.bcg.com/en-in/publications/2018/artificial-intelligence-factory-future.aspx
[20] http://niti.gov.in/writereaddata/files/document_publication/NationalStrategy-for-AI-Discussion-Paper.pdf

India's national AI strategy, formulated by NITI Aayog, seeks to transform India into a leader in global AI by following a three-pronged approach under the headline #AIforAll, outlined below:

1. *Opportunity for Economic Impact:* Accenture estimates that if implemented throughout the whole economy, AI has the potential to boost India's annual growth rate by 1.3%. By 2035, this would add 1 trillion USD to the economy. This guideline calls for a modification of the existing market-driven approach more thoroughly inclusive of lagging industries so as to reap the greatest benefit of AI as a GPT throughout the economy.

2. *AI for the Greater Good:* the strategy seeks to optimize implementation of AI not around maximization of topline growth, but around the achievement of social goals. In this respect, recent advances in AI are ideally suited to working around challenges that have made these social problems remain salient. Geographical access barriers, financial exclusion, limited and asymmetrical market information, and the demands of urbanization all have potential AI-enabled solutions that can support quality of life, access to choice, and inclusive growth aligned with development priorities.

3. *AI Garage for 40% of the World:* India already serves as the source of IT solutions for much of the world, and AI is a simple extension of this existing competence. India's vast scale and complex development challenges lend it a natural advantage for large-scale piloting, testing, and implementation of scalable technology solutions to issues that implicate the rest of the developing world. At the same time, India's existing track record as an IT and services hub gives it a leg up on providing Artificial Intelligence as a Service (AiaaS). Finally, India's great diversity will aid in developing robust AI solutions adaptable to highly variable environments, whether different in language or landscape. These three forces have the potential to elevate India as the solution provider of choice for emerging and developing economies across the globe.

Government coordination is a prerequisite to reorienting AI development around social goals because so far, private efforts have failed to direct investment towards sectors with the greatest potential for externalities. As an example, agriculture has struggled to gain investment for AI implementation because it would require coordination between many stakeholders and technological interventions at many levels, while private sector actors have not invested optimally because existing challenges and constraints have resulted in collective action problems.

For these sectors central to ICT-driven development, government intervention can "crowd in" investment by providing infrastructure access, supporting innovation through research, catalyzing partnerships between supporting firms, and generating demand for AI and ICT solutions to government needs. In agriculture, a potential way to activate the private sector would be developing a government-sponsored AI marketplace focusing on data collection, aggregation, and price modeling both for goods and agricultural services. With time, such a marketplace could develop both a supply and demand for AI services and would help identify the pricing metrics other private companies would need to

introduce their own platforms. Government coordination would also help India adapt to the future of work by supporting the development of new certification programs cognizant of affordability and access constraints, especially decentralized teaching in collaboration with the private sector.

Finally, ethical data usage and data protection have recently become topics of consternation in India, especially following the Supreme Court's ruling placing limits on the Aadhaar program over privacy concerns. At the same time, abundant and easily accessible data is a key ingredient in the development of successful AI responsive to the societal challenges it is designed to help resolve. To reconcile these competing goals, NITI-Aayog proposes the introduction of a new ethics framework surrounding data fairness, accountability, and transparency, incorporating data protection practices along international standards. A new, less narrow and stringent IP regime would also be introduced to bridge the gap between protecting innovation and encouraging collaboration, by, for example, making data easily available for developing new models while providing legal protection to finished products. New training for IP granting authorities and the judiciary would be required to close the gap in needs between AI developers and practitioners.

India's overall approach to AI, and ICT-driven development more broadly, can be summed up as pursuing a *late-mover advantage*. The government is quite cognizant of human capital limitations, and NITI Aayog's AI strategy paper acknowledges that the domestic technology sector is not yet prepared for cutting-edge research and applications of groundbreaking, homegrown ICT innovations. However, India can leapfrog ahead in its digital development by learning from successes and best practices around the world, while building domestic R&D capacity and biding its time until the sector becomes reasonably competitive. India's major tech companies, which are already structured as "systems integrators" which deliver technological solutions based on common practice rather than proprietary knowledge, are well suited for such an approach. Strategic public-private partnerships with these companies will allow them to focus their expertise in adapting existing solutions on India's development challenges, and eventually the rest of the world's.[21]

As far as AI is concerned, the report proposes introducing a Centre of Research Excellence (CORE), for improving understanding of core research, and an International Centre for Transformational AI (ICTAI), which would develop and deploy applied research in collaboration with the private sector. The former of these would build India's innovation capacity in preparation for competing at the international level, while the latter would build a market for the applications that could position India at the center of global AI-driven development once it is ready and able.

China

ICT services are already a major driver in the Chinese economy, and current investments indicate that Beijing sees AI as the next frontier in its socioeconomic development. By 2030, China estimates that 26% of its GDP will come from AI-related activities, and significant public spending has already been reserved for AI research via the central government, top-tier universities, and extensive public-private research partnerships. This publicly-funded

[21] https://foreignpolicy.com/2018/10/17/indias-sleeping-tech-giants-are-about-to-awaken/

research would strengthen a sector which has already saturated China with private sector investment and startups in areas like AI-powered fintech, chatbots, and AI-taught language learning.[22]

The Next Generation AI Development Plan, a strategic document published by the State Council in July 2017, outlines a roadmap towards another generation of rapid economic growth in China. In contrast with recent history, however, this plan envisions China transitioning from extensive, "catch-up" growth to intensive, innovation-driven growth. AI is seen as the keystone of this strategy, which builds a case for expanding China's theoretical development capacity, establishing a technological edge over other countries, and eventually leading the world in intelligent future technology development.

In contrast with India's "late-mover" strategy, which seeks to capitalize on earlier breakthroughs, adapt them to indigenous challenges and leapfrog to a point of competitiveness, China seeks to "pursue a first-mover advantage to become the world's primary innovation center by 2030." By being the first country to base development around Artificial Intelligence, China intends to gain a significant enough early technological edge to establish itself as the world leader in AI. This would allow industry clustering centered around Chinese AI companies to ensue, making the country a lasting, permanent leader in the space. The national AI strategy, and the "Made in China 2025" initiative more broadly, seeks to replicate the early successes that allowed America, a first mover in the early stages of the digital revolution, to assume its current role as a global hub of tech innovation.

To improve the likelihood of stimulating technological breakthroughs that could spark this transition, China has prioritized research in areas of "paradigmatic change," or fields of AI with high interpretative and generalization capabilities, high potential for interdisciplinary convergence, or clear applied objectives with the possibility of triggering AI technological upgrades. China also plans to focus its investment on sectors that have achieved the highest commercial viability. The first purpose of this is to drive the market-dominant commercialization of AI technology, leading to widespread adoption and usage. Second, this approach would intensify research in the best understood fields of AI, increasing the probability of breakthroughs in theoretical understanding.

Developing a theoretical research advantage over the rest of the world requires vast investments of human and financial resources. To build the necessary human capital early on, China plans to gather leading foreign talent through its "thousand talents program," which invites researchers to work in China. Domestic talent would be cultivated by introducing an AI academic discipline and integrating AI into professional training in all relevant fields. The strategy also calls on Chinese companies to leverage "international innovation resources" by "going out," or engaging in foreign mergers and acquisitions, equity investments, and venture capital for the purposes of reaping the benefits of foreign innovations. Over time, these efforts should reduce the current supply gap in domestic AI talent attested to by the aggressive efforts of Chinese tech companies to recruit leading talent abroad.[23]

[22] https://www.newamerica.org/cybersecurity-initiative/blog/chinas-plan-lead-ai-purpose-prospects-and-problems/

[23] https://www.newamerica.org/cybersecurity-initiative/blog/chinas-plan-lead-ai-purpose-prospects-and-problems/

The problem of financial resources will be addressed by introducing national AI "mass innovation bases," bringing together industry, academia, research, and production facilities in open-source entrepreneurship incubation platforms. The strategy envisions this type of deep integration between innovation ecosystems and industrial chains to allow more coordinated support platforms to emerge as well, such as common computing facilities and big data infrastructure.

However, China does not envision an entirely market-driven AI innovation ecosystem because its national strategy also places a high premium on preserving stability. The document places an emphasis on "safe, reliable and controllable AI development" which minimizes social risks while supporting applications in public security, national defense, and even the judicial system. On the one hand, the emphasis on social stability encourages a strong focus on establishing lifelong employment training systems to smoothly transition workers into AI-supporting roles. In other words, China intends to adapt to the future of work by preparing its workforce for shifting roles, responsibilities and knowledge requirements. On the other hand, the overwhelming focus on maintaining stability leads to a heavy focus on developing AI security and evaluation systems, coordinating military and civilian innovation resources, and integrating AI into the burgeoning social credit system. The fear of unfettered development means that the strategy envisions an investment system that, although market dominated, is "guided" by the financial administration. Substantively, this system does not differ greatly from the state capitalism which currently defines China's economy.

Key Issues/Challenges to Promote ICT-led Growth and Development in India

Lack of strategic federal initiatives and local capacity

At this point, India's national government has not fully assumed its necessary role as a catalyst in bringing together actors from the technology, financial, social, philanthropic and public sectors to create a national vision, motivation, and funding program for ICT-driven development. The only significant government initiative launched so far has been 2015's Digital India campaign, which sought to partner with these stakeholders to empower the technology sector and make government services available electronically through improved online infrastructure and increased internet connectivity.

While federal initiative lacks for fostering the development of national platforms for ICT-driven development, particularly for the benefit of rural areas, these platforms are further undermined by states' lack of capacity to use them. The EkStep platform, for example, is a free-to-use and complete platform meant to improve learning opportunities for primary-age children. But with limited federal promotion and cooperation with state and local authorities, adoption of the program has remained limited so far. Platforms to support both India's nascent national insurance system and its health and wellness centers initiative are likewise in early stages of development. While recent strategy papers have acknowledged both of these needs, the central government has not yet prioritized the implementation of these recommendations.

Societal limitations on internet access

Insufficient infrastructure and cost considerations are not the only barriers to internet access, especially for India's rural population. India also has one of the largest gender gaps for

internet usage in the world. In 2016, 70% of internet users were men, compared to only 30% of women. By 2020, these proportions are forecast to drop to 60% and 40% respectively, but this discrepancy will remain. According to a 2018 study by the regional ICT policy think tank LIRNEAsia, this gendered digital inequality is rooted in disparities in education, income, and awareness about mobile technology between men and women. A 2015 CCDS study found that with many women expected to stay at home, and lacking control over their own finances, they had no means to independently use the internet. In addition, when they were able to use the internet, many women were also monitored by close family members, and a heavy stigma was attached to women in poor communities using mobile phones coupled with a fear that the internet would cause women to go astray and be exploited. Without fully engaging half of its population, India will struggle to raise its digital adoption beyond its current level.

Lack of enhanced research capacity

India has succeeded so far in developing a digitally-capable workforce responsive to the demands of a global economy. But this success will prove somewhat illusory once India confronts the higher technical demands of innovating and applying AI and cutting-edge ICT solutions. The country will face shortages in and inconsistency of skilled expertise as it works towards becoming a leader in these fields, while issues of access and affordability will hamper efforts to fill these gaps.

While India may not yet be ready to direct cutting-edge research, the country plans to organize enhanced AI research efforts around maximizing a late mover advantage, leap-frogging in technical development by learning from successes and failures around the world, adapting existing technology to India's most pressing needs, and simultaneously building R&D capacity for future competitiveness. The AI Strategy Discussion Paper proposes two institutions for this: a Center of Research Excellence (CORE), which would consolidate understanding of existing core research and generate new knowledge to enable technological breakthroughs, and an International Center of Transformational AI (ICTAI), which would develop and deploy applied research targeted toward private sector collaboration. These two bodies would operate under an umbrella organization directing research efforts according to analysis of global advances in AI technology, analysis of socio-economic needs, and potential for collaboration on the international level.

Key Issues/Challenges to Promote ICT-led Growth and Development in China

Exclusive Market-Driven Focus

Part of China's planned first-mover approach to an ICT-powered economy is the need to concentrate resource investments of all types in sectors that have already found success. Fields that have proven themselves as solid investments will attract more capital than sectors which have lagged behind, increasing the likelihood of theoretical technological breakthroughs in these sectors and eventually, technological dominance. However, the sectors at the center of ICT-driven development are precisely those which have not yet succeed in incorporating ICT. This reveals the need for public investments to allow the potential positive externalities from success in these sectors to take effect. But under China's current ICT strategy, such public investment in laggard sectors is unlikely.

Tension Between Stability and Innovation Priorities

China's first-mover approach also puts a heavy premium on encouraging innovation. Yet national strategies also voice a need to ensure that AI innovations both do not disrupt China's social stability and do contribute to solving the country's many social challenges. AI is an inherently disruptive technology, and in the early stages of development, when ethical, regulatory, and security frameworks are not fully evolved, it is unlikely that the cutting-edge innovation desired will not disrupt social stability. To China's credit, it anticipates the need to rapidly develop such frameworks. But the practices initially included in them will likely not anticipate the new, unforeseen challenges inherent in unproven technologies.

Lack of Proven Intensive Innovation Capacity

China's AI and ICT development plans hinge on an ability to produce world-class research at the bleeding edge of existing technology. This stands in contrast to China's existing development in the ICT space, which although innovative in its applications, builds on technology and knowledge already applied throughout the developed world. In order to become the first mover in ICT innovations, China must find world-leading research talent in the short term while developing the capacity to produce the same level of talent in the long term. The evidence indicates it has not yet done so. The Mercator Institute predicts that the Made in China 2025 Initiative may produce a few international champions, but will fail to "catalyze a comprehensive, broad-scale technology upgrading across the Chinese economy." And the founding director of Baidu's Institute of Deep Learning, Yu Kai, estimates the number of world-leading AI researchers in China at "between five and ten."[24] The plan does acknowledge these challenges, but has not formulated specific paths to overcoming them.

Reduced Space for Local Policy Experimentation under Xi

Under prior CCP premierships, local and provincial governments worked as low-stakes laboratories of policymaking in which different interventions could be tested out, assessed, and deployed nationally if successful. This "adaptive authoritarianism" succeeded because a collective leadership model, instituted under Deng Xiaoping to limit the excesses of the Mao era, succeeded in fostering a spirit of internal debate, honest internal reporting, and relative meritocracy within the party. Xi Jinping's consolidation of personal power has altered this dynamic. With Xi's assumption of direct control over a far larger share of government than his predecessors, officials' priorities have shifted "from showing results to showing loyalty," and bureaucrats have become more passive and less willing to take initiative without explicit orders from higher up.[25]

[24] https://www.wilsoncenter.org/sites/default/files/how_china_is_preparing_for_ai_powered_future.pdf
[25] https://foreignpolicy.com/2018/10/15/chinas-great-leap-backward-xi-jinping/

At the local and state level, this has discouraged policy experimentation at the very levels of government responsibie both for China's innovative governance and lack of centrally planned excesses in the recent past. Furthermore, the government has begun discouraging small-scale pilot programs in favor of policies enacted at the national level. Refusal to devolve power in part has caused provincial-level policy pilots to drop from 500 in 2010 to 70 in 2016, as reduced perceived reward and heightened career risk leads officials to let experimental reforms fall by the wayside. On top of this, secrecy around ongoing pilots has been heightened out of fear of negative publicity if they fail. This reduces space for civil society participation and using prior mistakes to inform future interventions.[26] In this newly repressive policy environment, leading applied research will not be the only field to suffer; introducing even widely proven ICT platforms and other innovative tools will fail, especially in low-stakes and underserved areas, unless the government is certain both of their complete success and their ability to mitigate all possible risks. Such risk aversion does not bode well for China's growth into a leader in ICT-driven development.

[26] https://www.economist.com/china/2018/08/18/local-experiments-with-reform-are-becoming-rarer-under-xi-jinping