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Crossroads of Artificial Intelligence: Higher Education and Research in India and China

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ABSTRACT

This paper offers a comparative study of India and China in higher-education reforms for the development of talent in artificial intelligence (AI), and in AI research. It analyses the AI development plans and strategies of the two countries, their automation readiness index, talent retention, and research output. The analysis is based on both primary and secondary sources including interviews, government and industry reports, and recognised rankings. The paper spotlights India's AI talent development.

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INTRODUCTION

In July 2017, China unveiled its 'New Generation of Artificial Intelligence Development Plan',[1] which outlines the country's pathway to becoming the world's leading power in artificial intelligence (AI) by 2030. Besides focusing on the theoretical and technological aspects of AI, the plan envisions ubiquitous applications covering manufacturing, education, medical care, smart cities, agriculture, and national defence. To achieve this goal, China is strategically refashioning its higher education sector as a launchpad for talent. From the knowledge economy perspective, strengthening the country's hi-tech talent base is essential to driving the fourth industrial revolution.[2] Therefore, the plan identifies creating a "high-end and efficient intelligent economy" as a key national task. It is estimated that by 2049, 278 million workers will be replaced by AI, "representing 35.8% of the current employment in China."[3] Notably, in its 13th Five-Year Plan (2016-2020), China gave the green light to "innovation-driven development" and enjoined upon its universities and research institutions to create "national technological innovation centres." To this end, China prioritised human resource development, setting the stage for itself to become one of the "world's most talent competitive countries".[4]

Similarly, India, an emerging economy, is striving to build itself into a knowledge economy so it can compete in the global market and pursue sustainable socio-economic growth and development. In July 2015, the government launched the Skill India Mission in line with Prime Minister Narendra Modi's vision of India as "the world's human resource capital." AI has assumed a pivotal role on this front, with the government think tank, NITI Aayog underlining India's emergence as an "AI Garage" (or "solutions provider") as a strategy for leadership in AI.[5] AI and data could contribute about US$500 billion to India's GDP by 2025,[6] with AI poised to add a further US$957 billion to the country's GDP by 2035.[7]

Broadly, AI entails human-like capabilities of machines or programmes in "perception, cognition, decision making and implementation."[8] Machine learning is a subset of AI, with examples of AI technologies including natural language processing and computer vision.

This paper outlines a comparative analysis of China and India's higher education reforms for AI preparedness and research. It covers AI development plans and strategies, automation readiness index, talent retention and research output. The paper illustrates India's case in the context of talent development. Challenges on fronts such as data availability, start-up funding and government subsidies are beyond the scope of this paper.

China and India lend themselves for comparison due to several reasons. First, China and India have the world's largest and second-largest higher education systems, respectively. Second, both are among the largest developing countries in the world, with China the second largest (US$14.1 trillion) and India the fifth (US$2.9 trillion).[9] Third, mainland China has the second-largest number of AI companies in the world (1,011 as of June 2018), specialising in voice, vision and natural language processing,[10] and India is swiftly catching up, with the fifth-most number of companies and AI jobs globally.[11]

AI DEVELOPMENT PLANS AND HIGHER EDUCATION STRATEGIES

In June 2018, NITI Aayog released a discussion paper on the 'National Strategy for Artificial Intelligence,' which incorporates education (including higher education) among sectors of focus such as agriculture and healthcare.[12] It underlined the "incremental value" of AI in reforming India's education sector in terms of quality and access.

Examples of potential use included personalised learning through adaptive tools, efficiently performing administrative tasks, customising professional development courses, and predicting "the need for student intervention to reduce dropouts or recommend vocational training."[13] Further, it identified preparing a new generation to harness the global AI revolution as a focus area for NITI Aayog.[14]

India's National Education Policy (NEP) 2020, released in July 2020, provides that all universities offer doctorate and masters programmes in core areas such as machine learning and in multidisciplinary fields ("AI" + "X").[15] The NEP also includes provisions for setting up a National Educational Alliance for Technology "to enhance learning, assessment, planning, [and] administration" at schools and higher education institutions.[16]

China's 2017 AI development plan, which predates India's own discussion paper, also highlights 'intelligent education' as a segment of AI application to provide a learner-centric environment. However, it is distinct in its emphasis on a connection between AI talent and the country's education system, outlining the following steps: building the "high-end talent team as the most important development of artificial intelligence"; improving the artificial intelligence education system; and strengthening "the talent pool and echelon construction, especially to accelerate the introduction of the world's top talent and young talent, and form China's talent highland of artificial intelligence."[17] This shows that China is taking proactive action by moving from a generic AI plan to a detailed action plan focused on post-secondary education.[a]

a China has previously released a number of AI-related policy documents, including the State Council Guidelines on Promoting the Healthy and Orderly Development of the Internet of Things (2013), Made in China 2025, Robotics Industry Development Plan (2016-2020), and the State Council Guidelines on Promoting the "Internet+" Action (2015).

In April 2018, China launched the Artificial Intelligence Innovation Action Plan for Institutions of Higher Education, which stipulates that by 2030, "colleges and universities will become the main force behind building the world's main AI innovation centres and will lead the development of a new generation AI talent pool to provide China with the scientific and technological support and guaranteed talent to put it at the forefront of innovation-oriented countries."[18] The AI action plan specifies the following key tasks: improving the scientific and technological innovation system for AI at colleges and universities; improving the training system in the field of AI; and promoting the translation of science and technology achievements into commercial products by colleges and universities in AI.[19]

The difference is evident in India's and China's core purposes as articulated in their policy documents. India's AI plan focuses on "social and inclusive growth," and its NEP 2020 has a perfunctory reference to the country's potential leadership role in the emerging fields employing AI and machine learning. In contrast, China's AI development plan is fiercely competitive, imbued with a fervour in building the country's "first-mover advantage." While China has an official blueprint dedicated to AI for post-secondary institutions, India does not have an exclusive action plan to revamp higher education institutions for AI readiness.

Also, the Indian policy document (2018) provides a broad-brush direction for course upgrades and training in AI, whereas China's 2018 action plan carries AI training-specific targets for 2020, including the development of 100 "AI + X" majors for interdisciplinary growth, the publication of 50 world-class undergraduate and graduate textbooks, the establishment of 50 AI schools, and the launch of 50 national-level quality open online AI courses.[20]

Clearly, higher education institutions have been accorded top priority in China's blueprint to win the race to global leadership. In contrast, India's new education policy is inward-oriented, prioritising "institutional restructuring and consolidation" and a "more holistic education" that is mindful of multi-faceted human capacities. To be sure, "inwardness" is not necessarily a pejorative; at times, systemic reform presupposes it. As the Indian government sets its eyes on a leadership role in AI, a thorough, dedicated action plan is needed. However, India has not yet moved past the discussion paper to formulate the AI strategy. Does India genuinely aspire to have a leadership role, or is it merely trying to join the bandwagon?

AI AS AN ACADEMIC DISCIPLINE

Various Indian universities have begun offering undergraduate degrees in AI or computer science and engineering with a specialisation in AI and machine learning.[21,22] The Indian Institute of Technology (IIT) in Hyderabad was India's first educational institution to offer a "full-fledged" four-year degree in AI in the 2019-20 academic year, with an intake of 20 students.[23] IIT Delhi has also set up a School of Artificial Intelligence to offer PhD courses starting January 2021, with postgraduate degree courses in the pipeline.[24] Further, the IITs have also partnered with Massive Open Online Courses (MOOC) platforms to offer courses on AI. For instance, IIT Roorkee and Coursera offer six-month certificate programmes in AI, machine learning and data science through diverse instructional methods such as video lectures, hands-on learning opportunities, and team projects.[25] This should enable professionals to "upskill" themselves in sync with industrial needs.

There has also been a spurt in AI-related initiatives at colleges/universities, companies, and governments.[26] Nearly four

dozen initiatives of educational institutions, primarily the IITs and Indian Institutes of Science (IISC), relate to the creation of research labs, specialised units/centres, and related programmes and systems, including the Department of AI (IIT Hyderabad) and the Centre for Cognitive and Brain Sciences (IIT Gandhinagar).[27]

Meanwhile, in March 2019, China's Ministry of Education approved the introduction of an AI major in 35 universities, including the Beijing University of Aeronautics and Astronautics, Shanghai Jiao Tong University, and Zhejiang University.[28] As of May 2019, 479 universities in China, accounting for nearly 40 percent of the country's universities, were offering big data-related majors.[29] It is premature, however, to compare the size of AI degrees programmes in both countries since it is not yet clear whether application approval has resulted in student intake in Chinese institutions.

AUTOMATION READINESS INDEX

The Economist Intelligence Unit's Automation Readiness Index ranks 25 countries for their preparedness for "intelligent automation" based on their innovation environment and labour market and education policies.[30] India is placed at 18, with its policy environment readiness for intelligent automation rated as 'emerging'. It ranks marginally better in the labour market and innovation environment categories, at 16th and 17th place, respectively. However, in the education policy category, India ranks 22nd of 25 countries.

At the same time, China is the 12th most automation-ready country on the index. In the education policy category, it ranks higher than India at 14th place. This difference is attributable to the "21st century skills [such as critical thinking and creativity] and knowledge" component of the education category, where India ranks 22nd and China ranks 11th.

Further, China's position is better in compulsory education[b] and early childhood policies, while India's score is better than that of China in post-compulsory education (for instance, in science, technology, engineering and mathematics, or STEM fields). South Korea is at the top spot in the education category due to measures such as soft skills advancement, fostering science and technology talent, and promoting lifelong education.[31]

UNICEF has also expressed concerns that Indian students, and other youth in South Asia, have fallen behind in acquiring 21st century skills.[32] The emerging consensus is that it is time for Indian students to future-proof their skills, which demands the reform of the existing institutions and the encouragement of vocational education, tailored to meet the requirements of 21st-century jobs. According to the 2017-18 Periodic Labour Force Survey, nearly 2 percent of those in the 15-59 age group in India have received formal vocational training, but this figure is lower than what was identified in the National Sample Survey (68th round) in 2011-12.[33]

Furthermore, India's National Skill Development Mission, launched in 2015 to develop a "well-trained skilled workforce" for economic growth and "sustainable livelihoods", largely covers basic and modular skills rather than high-level skills.[c] NASSCOM has cautioned that "India's vast IT workforce, which has powered the nation's growth in the IT services sector, is in danger of becoming obsolete unless the government supports a massive reskilling programme [such as through

b Compulsory education in China covers nine-year schooling in primary and junior secondary schools.

c Recently, it has taken key initiatives towards incorporating AI. For example, the Ministry of Skill Development and Entrepreneurship signed an agreement with IBM in September 2019 to train faculty members from Industrial Training Institutes in the basics of AI skills under the train-the-trainer programme.

tax incentives and tech investment fund]."[34] Currently, talent reskilling in India is mainly supported through workforce reskilling (company-led employee training) and training providers (such as Coursera, Digital Vidya and National Programme on Technology Enhanced Learning).[35]

TALENT RETENTION

Of the international AI talent pool, the US ranks first with 28,536 AI talents, followed by China with 18,232, and India with 17,384 AI talents; the numbers are based on researchers' issued patents and/or published English papers.[36] However, when it comes to the top AI talent based on H-index,[d] the developed world has the highest share.

Globally, universities account for 72 percent of international AI talents,[e] and China is home to several universities that have a high proportion of international AI talents, with "Tsinghua University having the greatest number of international AI talents" (822) and "Shanghai Jiao Tong University in second place with 590."[37] India's Vellore Institute of Technology is in third place. However, no Chinese or Indian university made it to the top ten list "by the number of top international AI talent."[38]

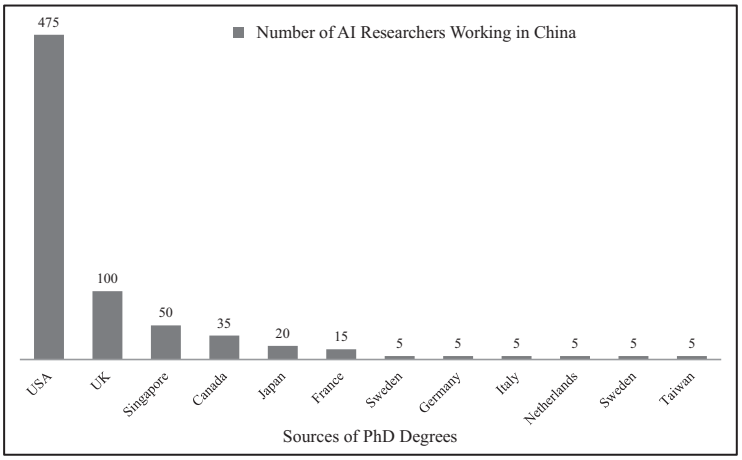
In addition to the low quantum of AI talent, weak retention is also an important issue plaguing the industry. According to the Global AI Talent Tracker, based on NeurIPS AI conference data,[39] "China is the largest source of top-tier researchers [TTRs], [based on researchers' geographic location] with 29% of these researchers having received

d H-index is a measure to evaluate an author's scholarly output and performance. It compares publications to citations; "there are *h* papers that have each been cited at least *h* times".

e The rest come from research institutions, enterprises and other entities.

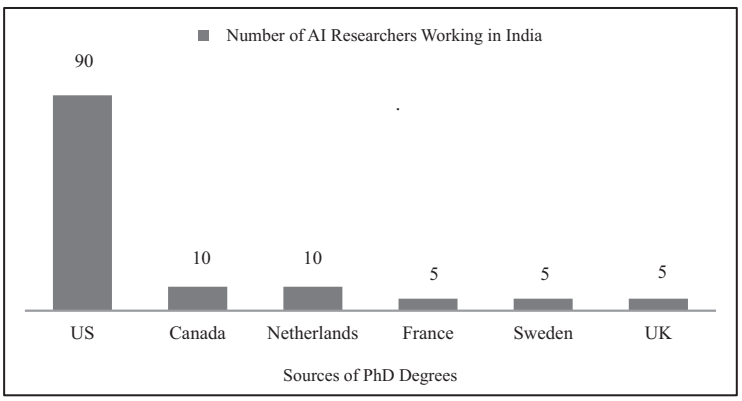
undergraduate degrees in China. But the majority of those Chinese researchers (56%) go on to study, work, and live in the United States." In comparison, India's share in TTRs is only 8 percent. China also fares better in the career progression of TTRs. Nearly 59 percent of top-tier AI researchers who got their undergraduate degrees in China went to the US for graduate school, and almost 33 percent of them are now working in the US.[40] In contrast, 70 percent of top-tier AI researchers who received their undergraduate degrees in India went to the US for graduate school, and half of them are today working in the US.[41] The better work environment and lifestyle, education and economic prospects in the US and other Western countries are determining factors in migration. Additionally, highly skilled migrants are drawn to "premier research institutions and sophisticated labs"[42] overseas. However, amid ongoing tensions with the US, China could retain more "homegrown talent." It has even launched a string of programmes to arrest brain drain, such as the Hundred Talent Programme (1994), 111 Programme (2005), Thousand Talent Programme (2008), Ten Thousand Talent Programme (2012), and Young Cheung Kong Scholar Program (2015).[43] China has also been able to attract foreign talent from a dozen countries, unlike India (see Figures 1 and 2).

Figure 1: Talent Inflow to China



Source: Author's own, 2019 Global Talent Report data[44]

Figure 2: Talent Inflow to India



Source: Author's own, 2019 Global Talent Report data[45]

Talent retention is even more critical given the shortage of skilled labour in AI—this is a global issue. But while skill deficiency among fresh graduates has been a common issue for Indian industries, the mismatch in the AI sector appears even more prominent. According to Aspiring Minds' 2019 Annual Employability Survey, "80% of Indian engineers are not fit for any job in the knowledge economy and only 2.5% of them possess tech skills in AI that industry requires."[46] Also, there is an uneven distribution of AI professionals in India, with most

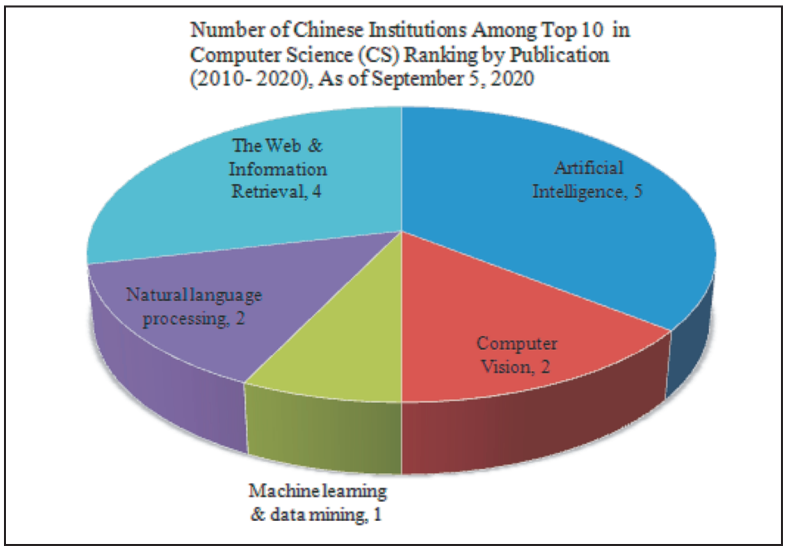
located in Bengaluru, Delhi National Capital Region, Pune and Hyderabad—all IT hubs with well-developed technology and digital infrastructure.[47] Similarly, in China, AI specialists are mostly concentrated in eastern and central regions such as Hangzhou, Shanghai and Beijing.[48]

RESEARCH OUTPUT, CITATIONS AND FUNDING

The geo-intellect model,[49] which maps China's global dominance in higher education, research and innovation paradigm, suggests that prowess in AI is a constituent of knowledge production. Broadly, the modalities of geo-intellect consist of shaping the architecture of educational governance; leading academic networks and alliances; establishing research centres and university campuses overseas; taking the lead in knowledge production; and hosting foreign faculty, research scholars and students as a marker of the attractiveness of Chinese institutions. AI is one of the building blocks of this ambitious enterprise.

Accordingly, China launched the Dubhe artificial intelligence open-source platform in August 2020, developed by Zhejiang Lab and Zhejiang University among others, to compete with the popular TensorFlow and Caffe platforms created by Western academics and firms.[50] It involves building a framework for the development of AI algorithms and fostering the AI cooperation ecosystem.[51] Further, in the AI areas of computer science—AI, computer vision, machine learning and data mining, natural language processing, and the Web and information retrieval—Chinese universities ranked among the world's top 10 in publication (by volume) between 2010 and 2020, as of 5 September 2020 (see Figure 3).[52] China's Tsinghua University and Peking University rank second and third globally, while India's IIT Delhi and IIT Bombay rank 110th and 120th, respectively.

Figure 3: Number of Chinese Institutions Among Top 10 Institutions in the Computer Science Ranking (by Publication Volume)



Source: Author's own, CS Ranking[53]

China's impressive record is also illustrated through the Web of Science (WoS) database; in search results for 'artificial intelligence' as a topic in the Clarivate WoS databases ("All Years" timespan, as of September 2020, and 'article' as the document type),[f] the US had the most publications, followed by China with 39,904 journal articles. In contrast, India had 6,009 journal articles published in the same period ("All Years" timespan), over six times less than China's. In the 2000-2010 period, China's[g] publication count stood at 4,782, while India's was 813; in 2011-2020, India's publications rose by over five times to reach 4,683, while China witnessed a spectacular rise with 34,687 publications in the same period—the most by any country.

f For an extensive search that goes beyond the generic phrase of AI and inclusive of many AI-related keywords/categories, see Tsinghua University's 'China AI Development Report 2018,' which shows that that China leads in the 1997-2017 timespan in AI paper output.

g The search included "People's Republic of China or China" in the country/region.

International collaborations have contributed to China's notable performance in research and output levels. China's top five collaborators are the US, UK, Australia, Singapore and Canada (with a combined 30-percent share in China's AI paper output).[54] On the other hand, India's top five collaborators—the US, China, UK, Singapore and South Korea—had a 22-percent share in the country's AI paper output.[55]

Additionally, just as China's double-digit economic growth was sustained through massive doses of capital investment, huge funding support has underpinned publications (in addition to China's requirement[h] to publish in the Science Citation Index journals,[56] which has recently been revoked). For instance, the National Natural Science Foundation of China (NNSF) funded 23,611 out of the country's 39,904 journal articles that show up in Clarivate WoS databases.[i,57] If only NNSF's funding contribution is considered, it is clear that nearly 60 percent of those publications (39,904 journal articles) were funded.[58]

In India, the Department of Science Technology in the Ministry of Science and Technology had the highest funding share, at 2.6 percent, of the country's 6,009 publications.[59] Even if all the funded publications were to be added up (without assuming the potential overlap of funding agencies), the total funding support is a mere 18 percent.[60]

An analysis of citations also reveals China's pre-eminence, which can partly be explained by the country's share in total publications. In the 2011-2020 period, there were 1,894 highly cited papers (HCPs)[j] in the

h For "academic promotions, job offers and allocation of research funding." (Sharma, 2020).

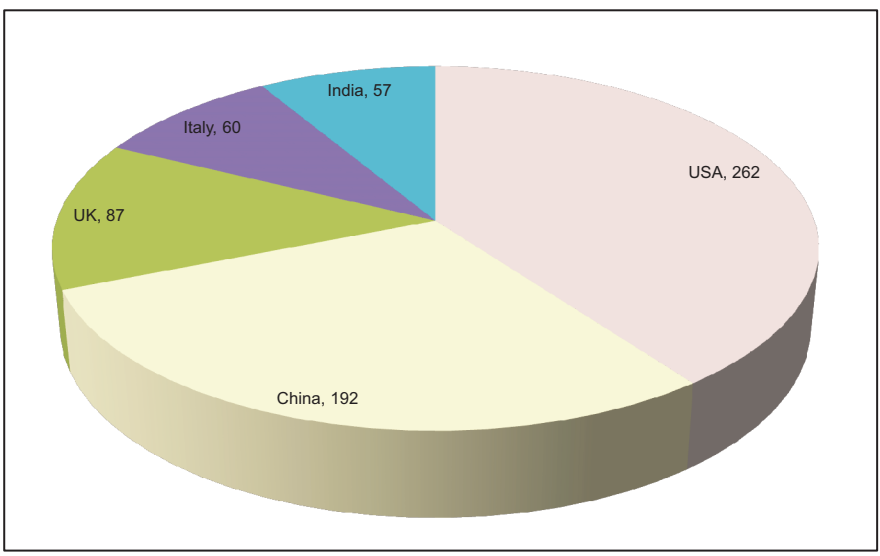
i This does not rule out funding by other national and international agencies.

j Web of Science defines HCPs as papers that received enough citations in a specific period "to place them in the top 1% of their academic fields based on a highly cited threshold for the field and publication year."

field (as of September 2020),[61] 894 of which were from China and 632 from the US. However, the US had a higher H-index, with 142,218 citations (excluding self-citations) while China had 117,809 citations (minus self-citations), and India had 5,680 non-self-citations for 60 HCPs. Apart from China, India was also surpassed by six other Asian countries in the number of HCPs—Singapore, Iran, South Korea, France, Japan and Malaysia.[62] The only silver lining for India is the consistent growth in the number of citations since 2010.

To assess the magnitude of knowledge output on timely topics, such as the COVID-19 pandemic, this author used the Clarivate WoS databases with the following keywords: artificial intelligence, machine learning, artificial neural network, natural language processing, pattern recognition, computer vision, image recognition, algorithm and deep learning. Of the 1,207 journal articles related to COVID-19 and AI (as of 26 September 2020), the US had the largest share, followed by China, the UK, Italy, India and Canada (see Figure 4).[63]

Figure 4: COVID-19 and AI-related Publications



Source: Author's own, Clarivate Web of Science Databases[64]

Patents are another metric of research output, with the highest number of patent applications being filed in the US and China, followed by Japan, South Korea, Germany, Canada, Australia and India.[65] According to the World Intellectual Property Organization, "Around one-fifth of the top 500 applicants, ranked by number of patents, are from universities and public research organizations from China. The highest placed such organization is the Chinese Academy of Sciences, which has 2,652 patent families, placing it 17th in the overall list of applicants."[66] Meanwhile, India is at most an "emerging" target for patent filing.

GENDER DIMENSION

The share of women in India's workforce declined from 32 percent in 2005 to 23 percent in 2019, which is attributable to factors such as the shrinking agricultural sector, cultural issues and the increased participation of women in higher education.[67] Yet women make up a sizeable number of India's AI professionals, at 24 percent,[68] which is higher than the global average (22 percent).[69] This shows that there is great potential for women's participation in AI and related fields.

According to a 2019 report on gender diversity in AI research, India ranks at 18 out of 34 countries in the "share of papers with at least one female author," and 16 in the "unique female authors" category.[70] Malaysia is the only Asian country ahead of India in both categories.[k] China was excluded from the sample because of a "relatively low accuracy with Chinese names of the name-to-gender inference system,"[71] making it difficult to compare India and China on this front. However, in 2018, China was ahead of India in women's authorship of

k Turkey, ahead of India, falls in the transcontinental region.

international academic conference papers in the field of AI.[l] In this context, in global comparison, both India (17 percent) and China (22 percent) were among the top ten countries with "the highest percentage of female authors."[72] From this perspective, women in both countries are actively contributing to the field of research in AI.

THE INDIAN CONTEXT: CHALLENGES AND OPPORTUNITIES

India's corporate sector is seeing a swift AI penetration. According to the *2020 Great Learning Report*, the Indian AI industry generated revenue worth US$415 million in 2019, up from US$230 million in 2018; the country's AI workforce grew from 40,000 in 2018 to 72,000 in 2019; and the number of newcomers joining the field rose from 3,700 to 6,000 over the same period.[73] The report is based on a survey of Indian professionals in the AI and machine learning industry, with respondents being from "across different business verticals including customer service, BFSI, medicine and healthcare, retail, e-commerce, IT products and services and manufacturing."[74] Furthermore, the average penetration of AI skills in India in specific sectors (software and IT services, hardware and networking, education, finance, and manufacturing) is "2.6 times the global average across the same set of occupations."[75] In fact, in the first four sectors (software and IT services, hardware and networking, and education), India tops the list of the 12 countries surveyed,[m] while China is at the top (in terms of the penetration of AI skills) in the education sector. However, the report is confined to data from LinkedIn.

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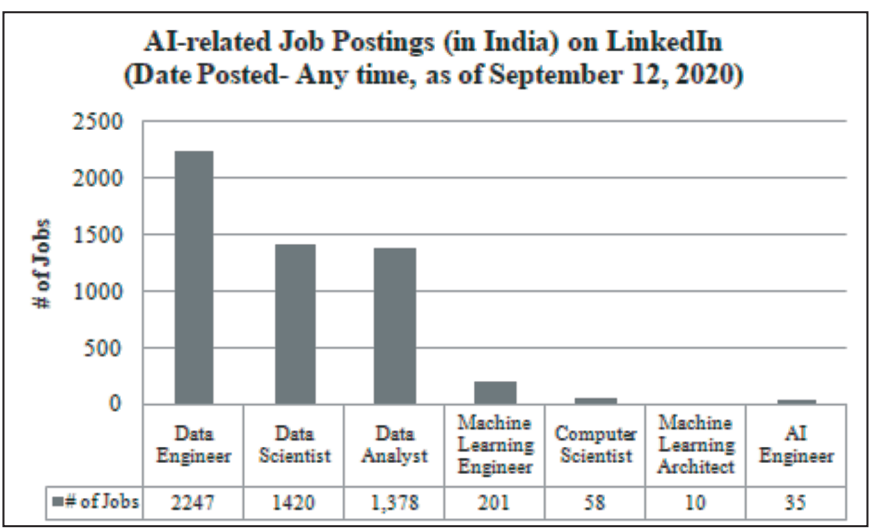
l The 2019 Global AI Talent Report derived this data from the analysis of 21 international conferences.

m The other countries are: the US, France, Israel, Sweden, China, Spain, UK, Canada, Singapore, Netherlands and Italy.

The *AI Index 2019 Report* also states that apart from Singapore, Brazil, Australia and Canada, India had the fastest growth in AI hiring between 2015 and 2019.[76] The acceleration in AI momentum is evident in the growth in business intelligence and AI-supported optimisation of enterprise processes, upgraded data management "across Indian organizations, and the increasing use of chatbots and NLP voice assistants."[77]

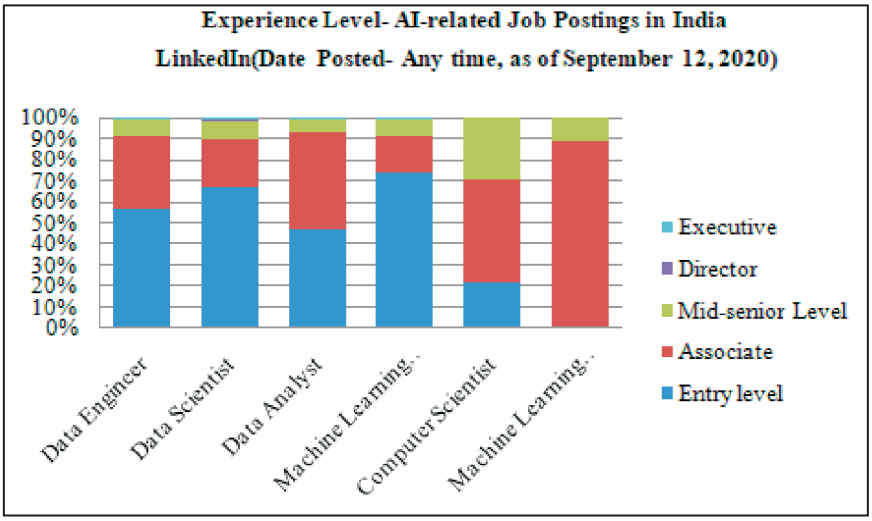
Significantly, the growth in the AI workforce has mostly been driven by "experienced professionals who have transitioned into a career in AI by upskilling themselves over the last few years, with 65% of AI professionals in India transitioning to their current role from other fields in the last 2 years."[78] This suggests that India's higher education sector needs a revamp from a skills perspective, especially since AI skills are required in entry-level positions as well. Out of a sample of AI-related job openings in India posted on LinkedIn, entry-level experience requirements are prominent in data engineer, data scientist, machine learning engineer and AI engineer roles (see Figures 5 and 6).

Figure 5: AI Job Postings in India



Source: Author's own, based on LinkedIn search

Figure 6: Experience Level-AI Job Postings in India



Source: Author's own, based on LinkedIn search

The government has already turned its attention to developing AI as an academic discipline, but the availability of qualified and experienced faculty will also need to keep pace with any growth in the number of programmes offered. According to the 2018-19 All India Survey on Higher Education, 880,349 students were enrolled in computer engineering at the undergraduate level (527,252 males, and 353,097 females),[79] the highest compared to other engineering and technology streams, and a 15-percent increase in enrolment from the 2015-16 survey findings (764,799 students enrolled for computer engineering at the undergraduate level). This trend underlines the critical need for faculty.[80]

Several computer science experts based in northern India shared opinions with this author on the supply of faculty.[n] One expert pointed

n Anonymity has been maintained to protect participants' identity, per the UBC Behavioural Research Ethics guidelines.

out that the IITs had at least a circulation of talent within their community, while another said that graduates from non-premier institutions might gravitate toward lucrative positions in the Indian corporate sector. Indeed, an analysis of AI-related faculty profiles at IIT Delhi, IIT Kharagpur and IISC Bangalore reveals that most received their doctorates from an IIT, IISc Bangalore or universities in the US. Similarly, Anna University and Vellore Institute of Technology see a massive absorption of their alumni as faculty members for AI-related courses.

Academia, industry, research and entrepreneurship require a consistent flow of talent that will nourish and strengthen the AI ecosystem in India and elsewhere in the long term. At the same time, proper career guidance at educational institutions is indispensable in tapping the brainpower of India's huge young demographic.

Educational course formats need changes as well. The *Annual Employability Survey 2019* shows that India's engineering education is mostly theory-based, with "little industry exposure—only 47 percent of students attend industry talks, while 60 percent of faculty do not discuss how engineering concepts apply to industry."[81] Therefore, fostering university-industry collaboration is key in training future engineers. Partnerships between post-secondary institutions and tech firms, including startups, to offer vocational courses will benefit the AI industry by supplying a skilled workforce and upgrading course curricula. NITI Aayog's ATAL Innovation Mission aims to impart 21st-century skills such as collaboration and problem solving through "self-learning," and to boost innovation and entrepreneurship. It has launched Atal Tinkering Labs (ATL) AI modules and ATL AI Step Up Module to build "a generation of young student innovators at the grassroots level."[82]

As for impetus for research, India's 2020 NEP refers to the role of the National Research Foundation (NRF) to "fund outstanding peer-reviewed research and to actively seed research in universities and colleges."[83] In the context of AI research, the policy states that the NRF may consider "a three-pronged approach: (a) advancing core AI research, (b) developing and deploying application-based research, and (c) establishing international research efforts to address global challenges in areas such as healthcare, agriculture, and climate change using AI."[84] The NRF's role in augmenting "high-quality" research in AI will be partly determined by its budgetary allocation and partly by the mindset of researchers to accomplish breakthroughs.

Finally, it is well recognised that the AI field demands experimentation, problem-solving skills and amenability to reiteration. Thus far, barring a few institutions, India's higher education system is plagued by rote learning and a scarcity of critical thinking. In other words, it has not harnessed the spirit of the relatively liberal democratic environment and has, therefore, not distinguished itself as a lever of excellence, creativity, and research rigour. For instance, computer engineers interviewed for this paper summed up their learning experiences at their academic institutions:[o]

> *"The way we were taught gave me the impression that critical thinking is not our [engineering] domain but the rise of AI challenges that opinion."*
>
> *"I don't know how many of us are driven by the passion to solve complex problems. We don't want to leave our comfort zone. I think*

o Seven professionals—IT and computer engineers—from northern India were interviewed. The interview questions pertained to their academic experiences studying in India and their recommendations for higher-education reforms. Responses of three participants were relevant for the AI segment of the project, as covered in this paper. The anonymity of the participants has been maintained to protect their identity, per the UBC Behavioural Research Ethics guidelines.

it's not the machine that's going to be automated, but we ourselves have become so!"

"I think there's a creative spark in us, and I had good, dedicated teachers. But the curriculum was a roadblock. That needs to change."

The engineers' responses point to a deeper malady in India's higher education system that must be addressed through reforms in both pedagogy and curriculum. This will include key elements such as regularly updating the syllabi in keeping with AI trends, strengthening the practical component through industry exposure, hypothetical scenarios and critical thinking-based projects, and incorporating multiple methods of assessing student learning.

CONCLUSION

Higher-education reforms are underway in India to foster AI talent, for example, by widening the incorporation of AI as an academic discipline. NEP 2020 provides for the setting up of the National Research Foundation, which should help boost research in AI. Certain impediments need to be overcome, including faculty shortage and outdated teaching methods. Above all, a clear-cut action plan for rejuvenating higher-education institutions for the development of AI talent, whether in industry or academia, is necessary for systematic reforms.

Meanwhile, China has been assailed by foreign observers for blunting its citizens' intellect through political indoctrination and "ideational regimentation."[85] More so, in China's monolithic Communist regime, the political application of AI involves real-time identification of "potential dissenters"[86] through digital surveillance of institutions of learning. China appears to be marshalling the energy of

its talent base through 'tech nationalism' if not through the free flow of ideas. Its top leadership efficaciously pumps out a grand vision to the citizenry,[87] and President Xi Jinping is known to read books on AI.[88] Undoubtedly, it is the Chinese central government's policy and financial support and the local governments' efficiency in meeting targets that move their country's AI agenda onward. But the politically-fired passion is no less significant. In the wake of the US blacklisting Chinese AI firm, SenseTime, co-founder Xu Bing was quoted to have said, "Entrepreneurship is a marathon, not a sprint. We will continue thriving."[89] The US Commerce Department alleged that the company had been involved in human rights violations against Muslim minority groups such as Uyghurs in Xinjiang.[90] Notably, SenseTime is "the world's most-funded AI pure-play with the highest valuation."[91]

Any comparison of India and China in AI boils down to China's lead in quantitative metrics. India has many milestones to achieve if it is to catch up with China. A clear action plan for talent formation (especially given India's so-called demographic dividend potential) and research output must be outlined. Future research may investigate faculty growth, enrolment in MOOCs, and AI startups to understand and compare trends in both countries.

But AI is no easy path for either country. Other than tangible and material factors, institutional commitment to excellence, politically open environment and the motivation of individual researchers to unlock the potential of AI will, in the long run, determine who gets into the top echelons. How Indian and Chinese institutions choose to define themselves in their countries' quest for AI supremacy—and what they will do to justify that description—remain open questions. ORF

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