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Bridging the AI Gap: India's Roadmap to Global Leadership

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By
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Aditya Mani

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1. Introduction

In 1997, IBM's Deep Blue supercomputer made history by defeating chess grandmaster Garry Kasparov, marking the first time when a machine had outsmarted a human (Chen & Chen, 2022). "For the first time in the history of mankind, I saw something similar to an artificial intellect," said Kasparov, describing the experience (Deep Blue, n.d.). This victory was not the beginning but the outcome of years of research and development in artificial intelligence (AI). While research into AI began in the early 20th century, it was only in the 1990s that it really took off, and there has been no going back since. Deep Blue's victory was a turning point that showcased the transformative power of AI, a technology that enables machines to mimic human cognitive functions like learning and problem-solving. AI has come a long way since its early days of playing games like chess; it has become a major determinant in global power dynamics and economic competitiveness. More than just a technological curiosity now, it is reshaping industries, redefining warfare, and realigning international relations, sparking a full-blown AI race. This high-stakes competition between nations seeks to harness AI's potential for economic, military, and geopolitical advantage, with the United States and China at the forefront (Pavel et al., 2023). Reminiscent of the space race from the past, the United States and China are leading this race, each investing heavily in their AI capabilities (Horowitz, 2018). The success could translate to substantial gains in economic power, military strength, and global influence. However, their approaches differ: the US emphasises open-source AI software and foundational research, whereas China takes a more centralised approach, utilising its massive data resources for rapid advancements *(The U.S.-China AI Race: Where Do Both Countries Stand?, n.d.)*. The US has traditionally led the way, but China is closing in fast, aiming to become "the world's premier AI innovation centre, with the quest to build up an AI industry of 1 trillion RMB (about $150 billion) by 2030 (Horowitz et al., 2018).

With the US and China at the forefront of the AI race, India's rise in AI has brought a whole new dimension to this global competition. Recognising just how important AI is strategically, India is keen to speed up its AI development. The potential is huge, with the AI market in the country expected to hit $8 billion by 2025, growing at over 40% from 2020 to 2025 (India Artificial Intelligence, 2024). AI is set to reshape the Indian healthcare sector too, with estimated expenditures reaching $11.78 billion by 2025 and a $1 trillion projected contribution to India's economy by 2035 ("IISc and TalentSprint's Pioneering Course on AI for Digital Health Is Preparing Professionals for the New Era of Healthcare," 2024). But these are just numbers. The reality is that AI is set to transform virtually everything from healthcare to defence to countless other sectors. And what is different about AI is its lightning-fast evolution. Unlike other technologies that take their own time to evolve, AI—especially with the rise of generative AI—is changing the game at unprecedented speeds. This means India cannot afford to sit on the sidelines. Even though the country has a lot going for it, like a large population that generates tonnes of data and a strong IT sector, the current pace of development suggests India may not be fully equipped to fully exploit AI's potential. There is a risk of falling behind. Therefore, to ensure India stays competitive on the global stage, it is

important to understand the challenges that are holding India back and look for ways to speed up progress in AI.

Leadership in AI offers more than economic gains; it is also about military strength and global influence. This raises the stakes for India considerably. Against this backdrop, this paper looks at the various dimensions of AI, the challenges India faces, and possible ways to catch up with the global AI leaders. The paper also takes a quick look at China's AI scene. While exploring India's challenges and opportunities in AI is valuable in its own right, a brief comparison with China offers further insights. This is because China, in many ways, makes a natural benchmark for India, as both countries share a lot in terms of socioeconomic contexts, global aspirations, and large populations with demographic dividends (Shenoy, 2024). As Jain (2020) notes, both countries have some of the largest higher education systems in the world, churning out a large pool of talent crucial for AI innovation. They are also two of the largest developing economies, both keen on using AI to turbocharge their growth. While China has already established itself in the AI space, with one of the highest concentrations of AI companies in the world, India is quickly attempting to catch up. It is important to note that this comparison with China is just meant to serve as a reference to get a better idea of where India stands next to its closest competitor. While a comprehensive comparison is beyond the scope of this paper, this lens allows for identifying potential best practices, pitfalls to avoid, and unique opportunities for India to leverage its strengths and accelerate its AI progress.

2. Artificial Intelligence and its Implications

It was Turing who created the first machine that used an algorithm in 1936, which is usually considered the start of modern AI (Madhavan, 2021). However, AI as a science was formally introduced at the Dartmouth conference in 1956, where John McCarthy coined the term "artificial intelligence" ("The History of Artificial Intelligence," 2006). So, what exactly is AI? Simply put, AI means developing computer systems and machines that can mimic human intelligence to perform tasks and decision-making. The tasks may range from making predictions and identifying objects to interpreting speech and generating natural language. By processing vast amounts of data and identifying patterns, AI systems can match or even surpass human cognitive abilities. While human guidance is certainly needed for AI decision-making, some advanced systems are designed to learn on their own *(What Is Artificial Intelligence (AI)?, n.d.).* At the same time, it should be noted that, like many other concepts, the AI's definition is not without disagreement, but the basic idea remains the same: AI refers to machines that are capable of performing tasks that traditionally require human intelligence.

When we take a closer look at AI, we realise it is a complex mix of several key components working together that drive its transformative capabilities. The key to AI is data that it uses to learn and make decisions. The ability of AI algorithms to identify patterns, make predictions, and generate insights largely depends on how large and diverse the datasets are (Khalifa & Albadawy, 2024). These AI algorithms are basically sets of instructions, which are the brains behind AI systems, converting raw data into usable knowledge. Machine learning, a part of

AI, is a crucial component that allows AI systems to learn from data on their own without the need for explicit programming. This makes them get better and better over time. This ability to learn is actually at the heart of AI's ability to take on complex tasks and make smarter decisions (Aldoseri et al., 2023). Natural language processing (NLP) takes AI to the next level by helping it to understand and communicate in human language. Computer vision is another part, allowing AI to interpret and analyse visual information, powering applications like facial recognition, object detection, and autonomous navigation. All of these capabilities are made possible by powerful computing that uses advanced hardware and software, crucial for running complex AI algorithms and handling massive datasets. This whole system of data, algorithms, machine learning, natural language processing, computer vision, and computing power forms the foundation of AI systems. As these elements continue to advance and integrate, they drive the rapid evolution of AI and its growing influence across various sectors of society.

AI is not just impacting industries but the very fabric of geopolitics. Changes are visible in transforming healthcare to enabling autonomous warfare and driving unprecedented productivity gains. Saying that AI is permeating every facet of modern life—including its bearing on international relations, which continues to grow by the day—would not be hyperbole. **Much like gunpowder redefined warfare and the internet revolutionised communication, AI is the next big disruptor, signalling a fundamental shift in geopolitics.** The AI market is expected to exceed $1.8 trillion by 2030 (Thormundsson, 2024), reflecting incredibly high global stakes. Geopolitical implications are becoming increasingly evident and are complex and significant. Take for example the rising tensions in the Taiwan Strait. A potential conflict there may not necessarily be about military might; it is also about how effective the AI systems are at powering each side's defences. George Takach imagines a scenario where China launches a missile strike on Taiwan, and in this high-stakes game, AI-powered defence systems could be the decisive factor. The ability to autonomously detect, track, and intercept incoming threats at lightning speed could mean the difference between victory and defeat (Takach, 2024). This is just one example of how AI is changing geopolitics beyond mere technological advancement. As AI becomes further integrated into military and economic strategies, its impact on geopolitics is undeniable, challenging traditional notions of power and influence in the 21st century.

While military might and economic resources still matter, how effectively a country harnesses AI's potential can be argued to reflect its technological prowess, particularly in its ability to collect, analyse, and utilise vast amounts of data. This data is what lets them create advanced algorithms and extract valuable insights. As stated above, this shift to data-driven power is reshaping practically every sphere, whether military, economic, or social. When it comes to the military, AI is revolutionising warfare, prioritising information over brute force. It is enhancing intelligence gathering, enabling predictive analysis for conflict prevention, and driving the development of autonomous weapons, fundamentally altering how military strategies are devised. Beyond the battlefield, AI is shaking up industries with predictive analytics, supply chain optimisation, and automation to rethink their strategies and tap into new growth and innovation opportunities. AI's influence is also visible in the social sphere, where social media analysis, sentiment tracking, and content generation are reshaping

public discourse, influencing politics, and even shifting the dynamics of social movements. These are just the tip of the iceberg of how AI is permeating various spheres, amplifying its significance in international relations and making it a powerful tool for global political and economic influence.

AI is undoubtedly changing the game, but it also brings the risk of creating power imbalances and a widening gap between haves and have-nots. This could largely result from unequal access to AI technologies, monopolisation of data, and concentration of AI technology and talent in select few regions. Since AI has found extensive use in businesses and industries, there is a growing concern that AI-driven automation could worsen already existing economic disparities by displacing jobs in labour-intensive industries, especially in developing countries, where the impact could be more pronounced. Besides, social control and surveillance through advanced technologies has long been a subject of debate, and AI has simply intensified this issue, particularly in the context of authoritarian regimes. Algorithmic bias in AI technologies has also been recognised as a major risk factor that may perpetuate societal inequalities and generate unfair results (ÜNVER, 2024). Yet, as AI continues to reshape the global power dynamics, nations are competing for position, and India is no exception, which is seen in its substantial investments in research and development to remain competitive. This competition is not just about technological prowess; it has significant implications for national security, economic prosperity, and global influence. India acknowledges the importance of AI and has set out on an ambitious quest to realise its potential. While China has established a lead in AI, India has its own strengths in terms of a vast pool of human capital, a rising digital economy, and a strong IT sector. Although challenges remain, India's commitment to AI, with projections suggesting it could add a remarkable $957 billion to the Indian economy by 2035, underscores its aspirations to become a key player in the global AI stage (Horowitz et al., 2018).

3. India's AI Footprints

India's journey into AI has been slow but steady. Recent years have seen the country's AI scene flourish, but this technological revolution has its origins in the pioneering works of figures like Professor H.N. Mahabala at IIT Kanpur (Madhavan, 2021) and Professor R. Narasimhan at TIFR in the 1960s *(Landscape of Artificial Intelligence/Machine Learning Research in India, 2018)*. While their early work led to further research and innovation, it was only in 1986 that India's AI aspirations truly took flight, thanks to the government's launch of the Knowledge-Based Computing Systems (KBCS) programme. Teaming up with the United Nations Development Program, this ambitious initiative set the stage for several major AI projects like machine translation for Indian languages, optical character recognition project, speech synthesis system, and image-processing facility (Madhavan, 2021). The 1980s and 1990s were key decades for AI in India. During this period, the Defence Research and Development Organisation (DRDO) established the Centre for Artificial Intelligence and Robotics (CAIR), focusing on AI technologies for defence. By the late 1990s, the transformative potential of AI had become increasingly evident, and the Indian government took a proactive step by launching the National Task Force on Information Technology and

Software Development, leading to the establishment of AI research centres across the country and integrating AI into the university curricula (Akshatsadachar, 2023). India's rise as a major AI player and the AI ecosystem we see today in India is the result of these foundational efforts, spanning decades.

As AI has advanced and its transformative potential is becoming clearer every day, the government has come to recognise that it needs a plan to make the most of what the AI has to offer. The result is the "AIforAll" strategy, which aims to position India as a leader in AI while ensuring social and inclusive growth. It focuses on five key areas: healthcare, agriculture, education, smart cities and infrastructure, and smart mobility and transportation. The strategy also talks about challenges like not having enough specialised talent, robust data ecosystems, and adequate computational resources. The strategy also emphasises responsible AI use, advocating ethical frameworks and data protection measures. For that, it proposes establishing dedicated research centres, promoting upskilling programmes, and creating a national AI marketplace, aiming to foster innovation and collaboration *(National Strategy for Artificial Intelligence, 2018)*. Taking a step further, India's National Education Policy (NEP) 2020 mandates AI-related programmes in universities and envisions a National Educational Alliance for Technology "to enhance learning, assessment, planning, [and] administration" at schools and higher education institutions (Jain, 2020).

As India gains a foothold in AI, it has rolled out several measures focussed on data, computing infrastructure, investments, skill development, regulatory frameworks, and international collaborations. Some of them include improving data accessibility and management through platforms like the Open Government Data Platform and the India Stack. Investments in computing infrastructure, such as developing supercomputers such as Param Siddhi and AIRAWAT, as well as collaborations with tech giants like Nvidia, have also seen an uptick. Investments are also directed towards foundational AI models for Indian languages. India's efforts are also focused on addressing the need for a skilled workforce, for which the country has undertaken upskilling initiatives such as YuvaAI and FutureSkills PRIME, with educational reforms aimed at integrating AI into the curriculum. On the regulatory front, India's focus is on striking a balance between encouraging innovation and addressing potential risks, as reflected in the proposed Digital India Act. This approach aligns with global discussions on responsible AI, emphasising trust and security through initiatives like the TRiSM programme (Nandi & Yadav, 2024).

Besides these efforts, India's AI journey got an unexpected boost in the form of the COVID-19 pandemic, which catalysed AI's adoption across various sectors. The country recorded the highest increase in AI utilisation (45%) among major economies globally (PricewaterhouseCoopers, 2020). India also joined the "Global Partnership on Artificial Intelligence (GPAI)" in 2020 as a founding member, demonstrating its commitment to not just harnessing AI's power but doing so responsibly and ethically, with a focus on human-centric development (Press Information Bureau, Government of India, Ministry of Electronics & IT, 2020). In 2024, in a significant move, the government injected over Rs 10,300 crore into the IndiaAI Mission to create a robust AI computing infrastructure through the IndiaAI Compute Capacity initiative. A cornerstone of the mission, this initiative seeks to establish a cutting-

edge, scalable AI ecosystem in India by deploying over 10,000 Graphics Processing Units (GPUs) through strategic public-private partnerships (Ministry of Electronics & IT, 2024). There is also a growing momentum surrounding the private sector's involvement in India's AI landscape, and these developments are no longer mere discussions; they have begun taking tangible shape in AI and related domains. Leading Indian conglomerates like TATA and Mukesh Ambani-led Reliance have not only announced but also commenced work on several important AI initiatives. This includes establishing massive AI-ready data centres, working on numerous generative AI projects (Bakshi, 2024), and building fabrication plants (Mukherjee, 2024). Plus, well-known IT firms like TCS, Infosys, Wipro, HCL Technologies, and IndaPoint Technologies are busy creating and offering innovative, scalable, and cost-effective AI solutions *(Top AI Development Companies in India: Leading the Generative AI Revolution, 2024)*.

The buzz around AI in India really shows that the country is making moves. But there are still some important questions to think about. Has India's journey into AI really taken off? Are all these announcements, investments, and promises leading to real progress? Even though India has made some impressive strides, a closer look suggests room for growth. The nation seems to have articulated a broad vision for AI, but the finer details and meticulous execution appear to be lacking. Compared to China, a country with a more or less similar population size, India seems to be lagging in several crucial elements that underpin AI advancement. A quick comparison with China, a dominant force in the AI domain, can offer valuable insights into India’s relative standing and where it needs to catch up.

4. How Do India and China Stack Up?

Research from Tufts University's Fletcher School has placed India in 15th place in the global AI race, way behind China's second-place position (Gupta, 2023). This might come as a surprise, given India's strengths—a strong IT industry, rapid AI adoption, and a population generating huge volumes of data. So, what is holding India back? Figuring out progress in AI is tricky, but there are some widely recognised indicators that can offer insights into where India has room for growth and improvement. These include talent, research outputs, patents, the number of AI companies, investment, and computational resources (Chahal et al., 2021).

Research is the backbone of any technology, and AI is no different. Even though India has made some important contributions to AI research, China is way ahead, indicating a stark asymmetry in research capacity. Between 2010 and 2019, there were 84,384 AI papers with at least one author affiliated with India, while for China, the number stood at 471,726, in fact, the highest (Chahal et al., 2021). China’s dominance is also visible in AI journal publications with a 39.8% share in 2021, while India's share grew from 1.3% in 2010 to 5.6% in 2021. China outperforms India in journal and conference citations, too, reflective of greater impact and recognition. In 2021, China accounted for 26.2% of conference publications, while India managed only 6.79% (Artificial Intelligence Index Report 2023, 2023). It is not just that they are publishing more; they are actually shaping the global discourse around AI. And when it comes to the dominance of Chinese institutions in AI research, they are making their mark.

Since 2010, the Chinese Academy of Sciences has consistently topped the list for global AI paper output, along with several other Chinese universities. In fact, in 2021, all the top 10 institutions publishing AI computer vision papers were from China, showing a strong investment in this key area. While American institutions are more prominent in NLP, the Chinese Academy of Sciences still leads, demonstrating its broad expertise. This dominance also covers speech recognition, another crucial AI component (Artificial Intelligence Index Report 2023, 2023). This gap gives China a real strategic edge, enabling it to develop cutting-edge AI technologies and applications that could significantly boost their economic growth, military capabilities, and global influence. Moreover, India and China differ in how they approach AI education and research initiatives. China has a lot more universities offering AI and big data programmes—about 40% of their universities provide these courses as of May 2019 (Jain, 2020). In contrast, India's efforts in AI education are more limited in both scale and variety.

Patent data shows a pretty big gap between India and China when it comes to AI innovation and commercialisation. While India is a key player in AI patents, China is in the driver's seat, holding 61.1% of all granted AI patents worldwide from 2010 to 2022. In comparison, India only managed to snag 0.23%. China also leads in AI patents per capita, and that number has shot up over the last ten years (Artificial Intelligence Index Report 2024, 2024). On the flip side, **India filed about 300 resident patent applications for every $100 billion of GDP, which is way behind China's 5,738 and the US's 1,253** (Nandi & Yadav, 2024). Several reasons explain why India lags in patent filings, especially in AI. The costs can be high, timelines are often unpredictable, and there is a shortage of specialised expertise in the patent office. Furthermore, ambiguous legal provisions, especially concerning software patentability, make it even tougher for India to ramp up its patent output in the AI space (Nandi & Yadav, 2024). When it comes to AI investments, China also takes the lead, especially in private funding. According to the AI Index reports, in 2023, China attracted $7.8 billion in investments compared to India's $1.7 billion. If we look at the total private AI investments since 2013, China has racked up $103.7 billion while India has only managed $9.8 billion. The difference is also clear in the number of new AI companies getting funded—China had 122 in 2023, while India had 45. This pattern has been steady over the years (Artificial Intelligence Index Report 2023, 2023). Overall, China is ahead when we look at the total number of newly funded AI companies since 2013 (Artificial Intelligence Index Report 2024, 2024).

Advancements in AI rely essentially on the computing infrastructure, a fundamental component of AI development and deployment at scale. This is what lets AI models process huge volumes of data, run complex calculations, and learn from the data to make intelligent decisions (Gupta & Ranjan, 2024). Consequently, the Indian government has made compute capacity a cornerstone of its IndiaAI Mission, putting over Rs 10,300 crore toward establishing a state-of-the-art AI computing infrastructure. The goal is to deploy over 10,000 GPUs through public-private partnerships, aiming to strengthen India's AI capabilities (Ministry of Electronics & IT, 2024). When we talk about a country's computing power, the number of GPUs is a key measure that gives a sense of its AI potential (Mohanty, 2024). But, here too, India is lagging behind China, which has an impressive 215 supercomputers on the

top 500 list, while India only has 3 (Chahal et al., 2021). And, not forget, India's cloud adoption—essential for scalable AI development—is still in its early stages.

These stats show a clear gap between India and China in AI capabilities, highlighting key areas where India really needs to accelerate its efforts to stay competitive. Despite India's strengths in higher education, economic growth, and IT leadership, this gap emphasises the importance of identifying and overcoming barriers to AI progress. Looking at these challenges alongside China's rapid advancements can help India better tap into AI's potential and strengthen its standing in the global AI scene.

5. India's Challenges in AI

Though India has a lot of potential in the AI space, becoming a major player is not all smooth sailing. This journey involves not only leveraging its existing strengths but also addressing challenges to establish a distinctive presence in the global AI landscape. How well India negotiates these obstacles will determine whether India's AI ambitions become reality.

5.1 Data

A critical challenge that India faces is the availability of data, often likened to "the new oil." High-quality data is what is needed for training AI systems, enabling them to learn, predict, and generate insights. It is the quality, accessibility, and representativeness of data that directly impacts the effectiveness and fairness of AI applications (Boulanin et al., 2020). Though India is considered a data superpower, thanks to its vast population generating huge chunks of data daily, just having tonnes of data does not translate into quality, accessibility, or representativeness. This is where the difficulties begin. India's current data landscape is fragmented, with datasets scattered across different institutions in inconsistent formats, making it hard to create cohesive AI solutions. Additionally, preparing raw data for AI algorithms is time-consuming and expensive (Nandi & Yadav, 2024). Consider the Bhashini AI initiative. Seeking to build a multilingual translation model for India's linguistic diversity, the project met obstacles because there aren't enough well-organised datasets for many Indian languages. A lot of regional languages have limited digitised data available to work with, which makes it challenging to build and train AI models (D'Monte, 2023). This brings up a larger issue—even though India churns out tonnes of data, the lack of standardised, high-quality datasets limits the development of AI applications that could meet India's specific needs.

5.2 Infrastructure and Resource Constraints

Data may be the fuel for AI, but the computing infrastructure is what really keeps the engine running. India's current computing infrastructure though has some major limitations. There are not enough high-performance computing (HPC) facilities, data centres, or cloud computing access. Energy and power costs are also high, and India depends a lot on imported hardware, which brings its own set of problems like high costs, cybersecurity risks, skill shortages, and market concentration. There is also a question of which types of semiconductors should be incentivised and produced locally (Corbyn & Morris, 2023). As

the demand for powerful computational resources—especially due to deep learning and generative AI—grows, India's current setup struggles to keep up. **It contributes less than 2% to the world's computing infrastructure,** which is reflected in its research output, also hovering around 2%. **In contrast, Indian researchers abroad are performing far better, contributing more than 12% to global research, owing primarily to better computing infrastructure.** The gap is even more obvious **when we compare India's numbers to the US and China, which together account for approximately 58-59% of global computing capacity, while India lags at sub-2%** ("India's Compute Infra Less Than 2% of Global Capacity: NVIDIA Asia South MD," 2024).

India needs to take a close look at its current and future computing needs to stay competitive. Boosting computing power is crucial for training accurate and high-performing AI models, allowing for the accommodation of more model parameters. And that means there is a growing demand for specialised computer chips, which are required for large-scale AI models. However, with most big tech companies, cloud computing services, and chip manufacturers concentrated in the US and a few other spots, these chips have become geopolitical tools to maintain dominance in the global AI economy. Chips are important, but cloud infrastructure is also needed to host AI models, which raises dependency on services like AWS, Microsoft Azure, and Google Cloud. Cloud costs are also a big concern for Indian companies; even the bigger ones are achieving only 20% cost optimisation, while smaller and mid-sized companies are having a tough time meeting their cost-cutting goals (Nandi & Yadav, 2024). There have been efforts to address this. In 2023, the government launched AIRAWAT, an AI-specific cloud computing infrastructure. The idea is to offer compute resources to startups, academics, and researchers without having to rely much on foreign service providers like AWS or Azure. Although AIRAWAT sounds impressive theoretically, its 656 GPUs are dwarfed by the supercomputers used by giants like Meta and Microsoft, with over ten thousand GPUs (Panday & Samdub, 2024). So, while projects like AIRAWAT are a step in the right direction, this compute capacity gap poses a significant challenge for India.

5.3 Reliance on Imported Hardware

India's dependence on imported hardware emerges as a significant challenge for building up its computing power, especially when it comes to critical components like servers, storage systems, and high-performance computing systems. India largely relies on countries like China, the US, and Taiwan for supplies of these essential items, including specialised components like GPUs, which are vital for training complex AI models. While there has been some progress in assembly operations, notably for smartphones, India still cannot produce many of the core components, such as semiconductors, which it often imports. China alone supplies 62% of India's electronic components, with South Korea, Japan, and Vietnam also playing major roles. Semiconductors, essentially the heart of any AI system, make up a large part of this import bill. India simply lacks the domestic fabrication plants needed to produce these crucial integrated circuits (Developing India as the Manufacturing Hub for Electronics Components and Sub-Assemblies, 2024).

To break free from this dependence, India's National Semiconductor Mission aims to develop a domestic chip industry and transform the country into a "Semiconductor Nation"

with over $10 billion in “production-linked incentives.” Less complex chips, including DRAM chips, smartphone chips, car chips, and display panels, are currently the main manufacturing focus of India (Panday & Samdub, 2024). However, India does hold a major edge in chip design, as 20 per cent of the global chip design workforce is based in the country, though the intellectual property (IP) for these designs is largely owned by foreign corporations. Moreover, the government has several support initiatives for chip design in place (Bhandari, 2023). Still, the main challenge lies in chip fabrication. While earlier attempts in this field failed, India has lately revitalised its efforts over the chip production process (Kumar, 2023). Notable developments include Tata-Powerchip Semiconductor Corp’s fabrication facility at Dholera, the Tata Group’s OSAT unit in Assam, the CG Power-Renesas Group’s OSAT unit at Sanand, and the construction of an OSAT plant by American company Micron building its OSAT plant at Sanand in Gujarat (“How India Is Spreading Itself Across the Chip-making Value Chain,” 2024). These efforts, however, come with significant challenges, not only in chip fabrication but across India's semiconductor industry as a whole. These include extremely high costs, land acquisition difficulties, a lack of streamlined and efficient regulatory processes, customs duties, and weak linkages between chip design and fabrication firms (Bhandari, 2023). A bitter reminder of the challenges that India faces in attracting players and building a self-sufficient semiconductor industry came when Taiwan's Foxconn withdrew from a $19.5-billion semiconductor joint venture in 2023 (“Foxconn Dumps $19.5 Billion Vedanta Chip Plan in Blow to India,” 2023).

Relying on foreign tech does not just hurt India's competitiveness; it also makes the electronics supply chain more vulnerable. Risks include increased costs, concerns about intellectual property, security risks, and delays in innovation. This could mean India end up stuck waiting for new semiconductor technology while other countries race ahead. It also puts the country in a vulnerable spot in terms of national security and economic sovereignty, with less control over the AI solutions tailored to its unique linguistic and cultural needs. We have already started to feel the impact of depending on imported hardware. High costs are already straining startups' and companies' budgets, making it harder to develop AI solutions. The government has come to realise the risks and is pushing “Sovereign AI” through the “Atma Nirbhar Bharat” vision. The goal is to give domestic production a boost, all while lessening dependence on imports across key industries, including AI. Self-reliance in AI refers to manufacturing more of these critical components, like semiconductors, domestically and establishing more data centres. But, self-reliance in AI is a rather complex affair because of the nature of the AI systems that are built on complex supply chains, influenced by various sectors, use cases, and stakeholders. Breaking free from the dominance of major global players in areas like chip manufacturing and cloud computing will require substantial resources, expertise, and time (Panday & Samdub, 2024).

5.4 Funding and Investment

Building self-reliance in AI is not just about developing technological capability; it is also about finances. Even though investments have increased in AI, especially from the private sector, the overall amount still falls short compared to players like the US and China. With access to capital being an obstacle, this hints at an AI and startup funding ecosystem still in

a nascent stage in India. **A Nasscom report states that by the second quarter of 2023, there were over 550 generative AI startups globally but only around 60 in India.** This raises a number of concerns, chief among them the lack of startups focused on building large foundational models—essential for many generative artificial intelligence applications. Moreover, as stated above, relying excessively on models from other countries limits innovation and customisation for the Indian context (Generative AI Startup Landscape in India: A 2023 Snapshot, 2023). Another challenge is language. Most foundational AI models are built for languages with a strong online presence, like English, while Indian languages often get left behind because they are seen as less profitable. Developing models for these "low-resource languages" needs a significant investment, but venture capital firms are often hesitant to commit "patient capital" for long-term data collection and model training (Nandi & Yadav, 2024). Data shows that 70% of Indian generative AI startups remain unfunded (Roy & Lohchab, 2024). This funding gap is especially evident when it comes to foundational models and enterprise-grade applications. Insufficient investment forces Indian startups to rely on existing models that might not be a good fit for the local context, which further hinders progress. Tackling this needs an increase in public funding to support the development of foundational capabilities, which often struggle to attract venture capital because of the longer time it takes to see returns. Adding to this challenge is the high cloud computing cost, which creates another layer of pressure for startups (Nandi & Yadav, 2024).

5.5 Skill and Talent

Besides funding, what plagues India's AI landscape is a critical shortage of skilled AI professionals, making it harder to develop and deploy AI solutions effectively and preventing the country from fully realising AI's potential. What is more concerning is that this skill gap is becoming even more troubling with the rise of generative AI. Companies need people with specific skills, but those are in short supply. This mismatch is a big roadblock to successfully implementing and scaling gen AI use cases across sectors. Projections suggest that AI could add a massive $957 billion to India's economy by 2035, equivalent to 15% of its current gross value (Horowitz et al., 2018). But, to fully capitalise on this growth, India needs to address the urgent issue of upskilling and reskilling its workforce. A report estimates that as many as 16.2 million workers will need AI training to meet the demands of millions of new tech jobs *(About 16.2 Mn Indian Workers Need to Be Upskilled, Reskilled in AI: Report, 2023)*. Despite having roughly 416,000 professionals working in AI and data science, India still needs another 213,000 skilled workers (Pany, 2023). And to add to that, AI-related hirings have been sluggish, and India lags behind as far as the concentration of AI talent is concerned. India does not rank among the top countries for AI talent concentration. However, there has been progress; since 2016, AI talent concentration has increased by 263% *(More than 18.56 Lakh Candidates Signed-up on 'FutureSkills PRIME' for Re-Skilling/Up-Skilling of IT Manpower, 2024)*. Yet, India, along with Israel and South Korea, of late has experienced a decline in the net AI talent migration figures, certainly indicating a worrying trend of AI talent leaving these countries (Artificial Intelligence Index Report 2024). With many of its AI talent opting to study, work, and eventually settle abroad, India also suffers from brain drain. The US, Australia, the UK, and other European countries happen to be the preferred destinations. The reasons are many, such as prospects for better and more impactful research, access to

better opportunities, and collaboration with a wider range of researchers and professors. Others are drawn by the promise of top faculty or research positions, which are more readily available outside India. Factors like limited government funding for research, a less mature AI industry, higher salaries abroad, and better infrastructure also explain this outflow (Sharma, 2024).

India's struggle to prepare a skilled workforce for the AI era results from how AI finds its place in India's education landscape. Even though the country offers a good number of English-language AI study programs, it falls behind when it comes to the number of programs per capita (Artificial Intelligence Index Report 2024, 2024). This is particularly concerning given the investment levels in research and development; for example, in the fiscal year 2020-21, India allocated only 0.64% of its GDP towards R&D—far less than what countries like China, Germany, South Korea, and the United States are investing (Sharma, 2024). The consequences of this underinvestment are far reaching. India produces a substantial number of engineering graduates, but most have hardly any access to world-class AI training and research opportunities. This leads to a brain drain in search of better opportunities abroad. Furthermore, the current workforce needs extensive upskilling and reskilling to acquire specialised AI skills. A recent study identified five key skills for upskilling—data analysis, digital skills, complex cognitive skills, decision-making skills, and continuous learning. Also important are evergreen skills like leadership, interpersonal skills, and communication (Jaiswal et al., 2022). Addressing these skill gaps continues to be a challenge for India.

India faces a multitude of challenges in AI, but these challenges are not insurmountable and should not deter India from realising AI's potential. This is because the country already has a strong foundation in place across domains, albeit with some gaps that need to be addressed. Nonetheless, the essential elements are present, and what is required is concerted efforts to bridge these gaps. China's impressive progress in AI offers valuable lessons for India, although with consideration for the distinct political, economic, and social contexts that differentiate the two nations. China's approach—emphasising AI education, investing heavily in research and development, following a focused AI strategy, moving early and assertively on commercialisation, and prioritising talent development and retention—offers valuable insights for informing India's own AI roadmap.

6. Bridging the AI Divide: Strategies for Success

India is at a crucial crossroads in the global AI race, and bridging the AI gap is not just an economic necessity—it is essential for securing the country's place in the 21st century. To this end, India must adopt a multi-faceted and comprehensive approach, requiring a coordinated effort on multiple fronts: strategic planning, investment, research and education, talent development and retention, infrastructure enhancement, industry adoption and commercialisation, and international collaboration.

6.1 Strategic Planning and Coordination

India needs a comprehensive national AI strategy for a structured approach to guide its AI development and deployment across the country. This means moving beyond broad aspirations and towards a comprehensive, actionable plan. A well-structured strategy can include allocating and directing resources efficiently, focusing on where they are most needed—research funding, talent development, or infrastructure. It should cover steps for investing in research, establishing AI hubs, targeting specific industries, developing skilled talent, creating strong AI governance and data utilisation frameworks, and fostering collaborations and partnerships. An organised approach like this would maximise the use of AI capabilities while avoiding fragmentation of efforts. Although India's AI strategy is a decent start, it could be enhanced with a more action-oriented and results-oriented approach. To this end, India needs to nail down a few things—clear priorities, a timeline, and specific, measurable goals. An illustrative example of this is China's AI strategy, which aims to make the country a global AI leader by 2030, with set milestones for 2020-2025 and 2025-2030. This focused approach builds a sense of direction and confidence for investors, something India's AI strategy seems to be missing. While India's AI policy sounds promising on paper, it is short on details about how it will actually be executed (Kumar, 2021). There is no clear plan for how AI will shake things up across industries, which is vital for boosting the economy. Meanwhile, China is getting behind its tech giants like Baidu, Alibaba, and Tencent to take charge of AI innovation. India's strategy does talk about ideas like the "Factory of the Future", but it does not spell out how such ideas will be put into action *(National Strategy for Artificial Intelligence, 2018)*. Also, India has yet to come up with a dedicated industrial policy for AI, though there is some buzz about Industry 4.0 (Kumar, 2021). This gap is actually an opportunity—India could tighten up its AI strategy and create a solid roadmap for its AI journey.

A more streamlined and well-coordinated approach that connects industry, government, academia, and other important stakeholders under a single framework could prove valuable to India's AI strategy. Setting up a central entity that acts as a hub for collaborations would make it easier to bridge current gaps, creating a well-rounded environment in which everyone can bring their strengths to the table. The rationale for this collaboration is clear: no single entity possesses all the necessary resources required for effective AI development. For instance, while having access to capital, the private sector may hesitate to invest in long-term research. The government, while willing to fund high-risk ventures, often lacks technical expertise. Academia faces difficulty retaining top AI personnel, as the private sector offers higher pay. And while tech companies are big on innovation, they may not always prioritise ethical considerations or regulatory compliance (Sharma, 2018). India's current AI framework acknowledges the need for a streamlined approach to AI initiatives. Although it does not particularly call for a specialised AI body, it does highlight the need for entities such as the "Council for Ethics and Technology" and the "Centre for Studies on Technological Sustainability" (CSTS*) (National Strategy for Artificial Intelligence, 2018)*. The operational details of how this would function are still not fully defined. However, these proposals may indicate a move towards more centralised oversight. This approach has been tried in several countries, including China, to help coordinate AI activities across different

sectors, optimise resource allocation, and encourage collaborative efforts between government, industry, and academia. India's own AI document highlights that many governments have established or utilised existing centralised umbrella bodies for budgetary planning of AI interventions, formulating strategies, and drafting *policies (National Strategy for Artificial Intelligence, 2018)*. India, by adopting a similar approach, can not only speed up its AI development but also become an AI norm-setter for the global south, leading regional initiatives and shaping the discourse on responsible AI use (Sharma & Ramann, 2023).

Next, India needs to consider re-evaluating its AI strategy to balance its commitment to social and inclusive growth and the need to stay competitive in the global race. While India's AIforAll strategy is commendable, there is an opportunity to enhance and expand its scope to propel India to the forefront of the global AI race. As outlined in its AI documents, India's strategy emphasises social development, explicitly stating that the country's approach to AI should prioritise optimising social goods over maximising topline growth *(National Strategy for Artificial Intelligence, 2018)*. While noble, it might inadvertently slow down innovation and commercialisation in the long run. As this approach prioritises tackling societal challenges, which is undoubtedly important, it might slow down progress in AI. By concentrating on applied research to address social issues, India might miss out on fundamental research that drives technological breakthroughs and long-term advancements. The focus on social development could mean longer timelines for AI projects and perhaps fewer resources for foundational research. However, a more competitive strategy does not mean giving up on using AI for social good. Instead, it is about finding the right balance, seeing AI as both a tool for societal benefit and a strategic asset for economic growth and strategic purposes. That would require India to empower its private sector to play a major role in unlocking the full potential of AI.

6.2 Empowering Private Sector

At first glance, prioritising social good could seem to stifle the innovation and agility a vibrant private sector offers. However, China's case shows that combining social good with strategic AI development is possible. Perhaps India could adopt a similar approach, where, by taking the private sector on board, AI serves its people's needs and broader ambitions on the world stage. However, when it comes to the role of the private sector, India seems to display reluctance in certain aspects of implementation, such as those related to responsible AI (Responsible AI, 2021). This caution is particularly evident in areas like defence and military, where the private sector has not historically played a major role. Even though the government has attempted to open up the defence industry to the private sector through initiatives like Atmanirbhar Bharat and Make in India (Behera, 2023), it is still mostly the public sector taking the lead in AI development here (Levesques, 2024). Despite this historic preference for public sector leadership, India's AI strategy acknowledges the role of the private sector in its AI ambitions, though with some reservations.

Looking at the rapidly changing AI landscape, the private sector leads the way in this transformation. Companies like OpenAI, with its groundbreaking ChatGPT, Google's Gemini, and other AI powerhouses from the US and elsewhere, are not only pushing the boundaries of what is possible with AI but have also set the stage for a whole new era of technological

advancement. The private sector has a few key advantages, making it a perfect fit to drive AI progress. Plenty of resources, emphasis on practical applications, and ability to draw top talent position it perfectly to lead the charge. In its post-liberalisation age, India has already seen the transforming potential of the private sector. It is now taking place once more in AI. The private sector is outpacing academia in innovation, fuelled by industry-led research and collaborations. Numbers speak for themselves. In 2023, industry-led research and collaborations produced 51 machine-learning models, compared to just 15 from academia (Fell, 2024). As AI models become more complex, they need more resources, giving the private sector an edge thanks to their access to data, computing power, and funding. In fact, the private sector happens to be the origin of most foundational models, with industry accounting for 72.5% of them in 2023. Top AI talent is also flocking into the private sector; AI PhD graduates are increasingly leaving academics for jobs in industry. This trend is exacerbated by a declining number of industry experts who make the transition back to academia. The numbers speak for themselves. In 2023, private investments in generative AI soared to $25.2 billion, about nine times the 2022 investment and thirty times the 2019 investment. The US leads the way, followed closely by China, while India is still catching up. The US also tops the list of cumulative investments since 2013, thanks to its robust research ecosystem, supportive regulatory environment, and the presence of major tech companies actively investing in AI (Artificial Intelligence Index Report 2024, 2024).

Given its vital role, India's path to becoming a key player in AI depends on empowering its private sector. The private sector is positioned to play a crucial role in the AI revolution, just as it was the driving force behind the shift that pushed the country into being one of the world's leading IT powers. Private businesses have always led the way in innovation, from the early days of computing to the expansion of IT services, opening doors that have shaped India's reputation globally. Strategic government policies and reforms in the 1980s and 1990s opened up the private sector's potential, enabling it to drive software development and technological advances. In addition to merely filling the voids left by the public sector, companies such as TCS, Infosys, and HCL contributed to India's reputation as a global hub for IT innovation and services. The lessons from the IT revolution are clear—while government support is essential, it works best when it supports private innovation. This is just as true for AI. The private sector has everything—agility, resources, and global connections—needed to push the limits and compete internationally. As it did in IT, if the private sector rides this momentum in AI, the outcomes might be transformative. By focussing on innovation, scaling up investments, and harnessing India’s vast talent pool, companies can push beyond just services and develop AI products, platforms, and solutions for the global market. Indian companies have certainly made progress in AI, but what is truly needed now is a collaboration among the private sector, universities, and the government. If they can create an ecosystem that supports startups and encourages taking risks, India has an opportunity to emerge as a leader in AI.

India's AI policy recognises that the private sector has a major role to play in driving innovation with its resources, technical know-how, and market knowledge. The strategy proposes establishing International Centres for Transformational AI. The industry would run these centres, with the government pitching in to help and provide support while the private

sector takes charge of innovation and development. It also pinpoints areas where the private sector might hesitate to jump in. This will, therefore, require government support due to limited private-sector participation. In these cases, the government needs to step in and encourage large-scale AI interventions that private companies might not pursue because of lower immediate returns. Another important area where the government should step in is promoting AI use in the IT industry. It might sound surprising, but in spite of its global prominence, the Indian IT sector has been a bit slow in embracing new digital technologies like AI. Since startups and smaller firms are poised to be the "engine for growth" in India's AI aspirations, the strategy proposes creating incubation hubs and venture funds specifically for AI startups to fuel their growth. There is also the idea of a National AI Marketplace (NAIM) to encourage participation from private enterprises, startups, and academic research institutions, fostering collaboration and exchange of AI solutions (National Strategy for Artificial Intelligence, 2018). There is no doubt that private investment in AI is crucial, but India's funding scene is still limited compared to other big players. Addressing this funding gap is crucial since this funding gap significantly affects the growth of a strong AI ecosystem in India (Artificial Intelligence Index Report 2024, 2024). Take the recent drop in funding for Indian AI startups, for example—there was a shocking 80% decline in 2023 compared to the year before. Meanwhile, AI investment is rising in the US, with investment in startups jumping by 211% (Singh, 2024). To bridge this gap, India needs to focus on attracting local and foreign investors to support its AI industry. This means creating a more welcoming investment environment, offering incentives, encouraging collaborations, and simplifying the regulatory processes.

6.3 Collaboration

AI knows no boundaries, making strategic international collaborations important and much needed. According to Mohanty and Singh (2024), collaborations, especially between India and the United States, are critical for India to overcome the challenges in its AI journey. These partnerships could boost progress in areas like setting common standards, sharing advanced computing resources, promoting data sharing while ensuring privacy, strengthening cybersecurity, lowering export barriers on high-performance computing systems, easing visa requirements for Indian talent, and encouraging innovation and skill development. Working collaboratively, India and its international partners can create a space that embodies democratic values like equity, fairness, transparency, and inclusivity, ultimately fuelling mutual growth and progress in AI (Mohanty & Singh, 2024). However, it is not just about partnering with other countries; India should also play a bigger role in international AI initiatives, like the proposed 'AI study group' within BRICS (Sharma & Ramann, 2023). By leading or actively participating, India can learn from global best practices, share its own unique perspectives on the global AI discourse, and facilitate technology transfer, joint research projects, and talent exchange—all essential to driving AI innovation and adoption. There is also a need to bring together industry and academia, as well as connect AI companies with more traditional industries. For far too long, AI research has been fragmented, with academia and industry operating in isolation. China's approach serves as a valuable lesson here; it brought together academia, smaller enterprises, and major tech companies to build a vibrant environment where knowledge sharing and

technology transfer flourish. Thanks to this collaborative approach, AI has quickly grown in both core capabilities and industry-specific applications (Nandi & Yadav, 2024). Replicating this success in India requires promoting industry-academia partnerships, crucial for cultivating a skilled AI workforce and ensuring India's competitiveness in the global AI arena.

6.4 Regulatory and Policy Framework

At the heart of it all, India needs a robust and clear regulatory framework. The back-and-forth seen lately around AI governance and regulation shows how this uncertainty can hold back innovation and collaboration. Not having a clear and comprehensive regulatory framework creates uncertainty, especially for foreign investors and companies wanting to engage in AI projects in India. For instance, in 2023, the government initially stated it would not regulate AI in India ("No Plan to Regulate AI, IT Ministry Tells Parliament," 2023), only to reverse its position two months later, announcing plans to regulate AI to prevent user harm ("Why India Can Afford to Wait and Watch Before Regulating AI," 2023). Similarly, in March 2024, an advisory required social media and other platforms to label under-trial AI models and seek government approval for deploying them ("Government Asks AI Platforms to Seek Approval for Deploying Under-trial AI; Makes Labelling Mandatory," 2024). However, this advisory was soon withdrawn, creating a sense of unease and confusion and drawing mixed, mostly negative reactions ("IT Ministry Replaces AI Advisory, Drops Requirement of Government's Permission," 2024). While regulations are necessary to prevent harm, the Indian government's current approach may be too restrictive and may be inadvertently stifling a technology that evolves quickly. As tech lawyer Rahul Matthan puts it, AI needs room to breathe. Innovation does not just happen in labs; it happens out in the wild, where entrepreneurs need the freedom to experiment and even make mistakes without fear of harsh repercussions (Deep, 2024). Regulations are necessary for responsible AI development, but being too strict or ambiguous is counterproductive, can kill innovation, and discourage potential investors looking for clarity and predictability. In India's case, the approach to AI governance is still a work in progress. Nonetheless, the current uncertainty is definitely a barrier. The government must create a stable framework that fosters innovation while ensuring responsible AI use. It is a delicate balancing, but one that is essential for India to unlock AI's potential.

7. Conclusion

India is well-positioned to capitalise on AI's potential and make a presence on the global AI scene as a result of its strengths, such as a thriving IT sector, a vast pool of tech talent, a great deal of data, and an exponentially growing digital economy. Recently, the government has sounded more serious about AI, announcing an AI strategy alongside various initiatives demonstrating a strong interest in realising AI's full potential. There are plans, commitments, announcements, and everything required of a government; however, a closer look suggests a gap between aspiration and reality. Despite progress, India still lags behind players like China in a few key areas that are essential for AI development. These include research output, patent filings, investment, computing infrastructure, and AI commercialisation. India is also struggling with challenges like poor data quality, limited accessibility, inadequate

compute infrastructure, and a shortage of skilled AI workforce, all holding back India's progress in AI. The young domestic chip industry and reliance on imported hardware also add to these challenges. Overall, while promising, India's efforts appear somewhat scattered and disorganised. Therefore, to stay competitive, India could benefit from a more focused and streamlined approach, like formulating an AI strategy with measurable goals and clear timelines, increasing investment in research, enhancing AI education and talent retention, improving compute infrastructure, and promoting international collaboration. Addressing these challenges, along with India's open market and dynamic private sector, provides a strong foundation for growth, particularly in the tech domain. This focussed approach could help India better channel its efforts and achieve its AI ambitions.

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