Enabling a $5 Trillion Indian Economy: A policy framework to catalyse AI-centric technology ecosystem

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Abstract

The classical approach in establishing a system based on first principles (or rules) has been eclipsed by a newer paradigm in which a system is constructed based on examples. This newer paradigm, the basis of contemporary Artificial Intelligence (AI), allows the creation of complex systems that were impossible to create a few years ago. Not surprisingly, this newer paradigm has rapidly been adopted in diverse disciplines for discovering, modelling, and inferring from data. Besides the growing excitement associated with its potential to catalyze discoveries, it also has the potential to have profound business and economic impact. With India aspiring to become a US$ 5 trillion economy in the coming years, it is essential to evaluate the role that AI can play in helping achieve that goal. This Paper examines the potential of AI in promoting economic growth and policies that may amplify the efficacy of AI in helping India achieve its growth aspirations.

Introduction

John McCarthy, popularly known as the father of Artificial Intelligence (AI), described AI as the "science and engineering of making intelligent machines, especially intelligent programs". McCarthy's notion set the stage for technocrats, policy analysts and thought leaders to advance research, policy dialogues, and deliberations related to AI. Such discussions have been steadily gathering momentum with the increasing realization of the significant impact that AI has on employment generation, research and innovation and quality of life.

India is looking towards AI as one of the key enablers of its vision of becoming a US\$ 5 trillion economy. Introducing the theme #*AIforAll* in 2018, India seeks to enhance the deployment of AI in growth-oriented sectors of the economy. A considerable funding outlay has also been earmarked by the Government of India (GoI, 2020) in the 2020-21 national budget to encourage the use of AI, data analytics and Machine Learning (ML).

It is thus an appropriate time for India to formulate a national policy framework governing AI so that it could appropriately leverage and promote the technology to realize rich socio-economic dividends. This paper examines the potential of AI, underscoring the need for a focused national policy in India to enable AI's effective contribution to technology oriented-economic development.

Literature Review

Though it is possible to specify a set of rules and induce a machine that can play a game of tic-tac-toe, it is impossible to specify rules as the complexity of the task increases. For example, imagine writing a set of rules for a self-driving car. Contemporary machine learning is thus largely based on "learning from examples" in which a machine is induced from data as opposed to being constructed from first principles or domain-specific rules. An impressive array of applications have already been demonstrated using this paradigm of "learning from examples" -- self-driven automobiles, clinical decision making, online chatbots, the design of new drugs, autonomous legal aids and robotic chefs to name a few. What is even more promising is that the systems constructed using this paradigm, in most cases, are able to out-perform existing state-of-the-art systems.

Not surprisingly then, AI has become central to various imperatives as nations seek to leverage it in boosting their economic output as well as improving the overall quality of life of its citizenry. In the next two sub-sections, I provide a concise summary of the expected impact of AI deployment and the sectors intended to benefit from it.

Across the globe

Multiple studies have estimated the economic gains from the deployment of AI. For instance, according to Bughin and Zeebroek (2018), AI contains the potential to bolster "additional global economic activity of around US$13 trillion by the year 2030", which could, in-turn boost the global Gross Domestic Product (GDP) by almost 1.2 percent per year. Similarly, Ghosh (2017) reports AI's contribution to the tune of US$ 15.7 trillion in the global economy by 2030. Moreover, it is estimated that over the years, the world could also witness significant labour productivity improvements and improved consumerism resulting from AI-driven product enhancements.

Liu (2020) highlights the surging revenues from an AI-driven software market. They have risen from a little over US$ 10 billion in 2018 to nearly 15 billion last year and which could further touch to US$ 126 billion by 2025. Aron and Sicular (2019) emphasize the enhancements in business values and productivity of workers as a result of AI. They say, "AI augmentation will create US$ 2.9 trillion of business value by the year 2021 and 6.2 billion hours of workers "productivity globally".

The literature also confirms the positive impact of technological advancement through AI on employment generation. The introduction of robotics and advanced machine learning techniques are expected to significantly open the job market (De Backer et al. 2018; Bessen, 2017b; Graetz and Michaels, 2018). According to Ernst, et.al. (2018), it is a universal phenomenon. Referring to the industrial revolution of the 19th and 20th centuries, they underline the fact that the wave of automation during that period led to an increase in demand for labour, primarily in technology-driven sectors such as manufacturing, mining, and construction. Malik et.al. (2018) has reported that AI augmentation could generate almost US$ 2.9 trillion in business value by the beginning of the year 2020, and the employment generation to the tune of almost 2 million by 2025. Gill (2018) underscores the interests stimulation among people generated from AI, deep learning and machine learning tools, in entrepreneurship for areas ranging from healthcare and medicine to Industry 4.0 projects.

A parallel argument in literature states that modernization in technologies is also causing widespread job displacements, job polarization, widening income gaps and inequalities (Korinek and Stiglitz, 2017; Méda, 2016). However, another set of studies also reveal that such displacements are counterbalanced by widespread job opportunities and skills development needs. For example, in the study undertaken by Malik et.al (2018), estimated that that 1.8 million jobs are expected to be eliminated by 2020 worldwide, but at the same time, another 2.3 million new jobs will also be created by then, as a result of AI.

The India story

In India, the growth of AI is expected to take the path of an S-Cure which depicts a slow start at the beginning and subsequent acceleration in the deployment of AI with increasing competition, leading to improvement in complementary capabilities.

AI has significant potential to value add and infuse growth in the Indian economy. According to Menon, et.al. (2017), AI is estimated to perhaps add 15% of the current gross value added (GVA) to India's GDP, which is almost US$ 957 billion, by the year 2035. Breaking this figure down, the authors have estimated that almost US$ 597 billion of the GDP is expected to be generated through AI-driven augmentation in factor inputs, another US$ 277 billion through AI-facilitated productivity enhancement and the remaining through intelligent automation. This means that it could boost India's annual growth by nearly 1.3 percentage points each year, leading to an additional US$ 1 trillion being infused into the economy over the years. This is quite a significant contribution to growth, in comparison to some of India's peers[i].

Studies and reports have also highlighted the nation-wide benefits of AI in terms of massive job creation, up-skilling and reskilling of the workforce and significant improvement in productivity in demand generating sectors. According to one such study from Malik, et.al. (2018), AI and ML are expected to absorb almost 9% of India's workforce in new employments. Moreover, Information Technology – Business Process Management is expected to be the highest employment generating vertical in India followed by infrastructure development, healthcare and manufacturing. Additionally, around 37% is expected to taken-up in jobs requiring radically changed skill sets with the diffusion of AI.

In the case of agriculture, the sector contributes nearly US$ 540 billion and employs over 50% of India's working-age population, there is ample evidence that technology intervention can lead to significant sustainable agrarian development in India (Kundu, et.al, 2020). Specifically, AI can be quite beneficial in improving the farmers' incomes. According to Menon, et.al. (2017), the earnings of the Indian farmers can rise by almost US$ 9 billion because of AI. Similarly, for Micro, Small and Medium Enterprises (MSMEs) that account for 30% of the country's GDP, AI-augmented interfaces intertwined with users' segmentation and predictive analysis can enhance and improve user engagements, over the years.

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[i] In comparison, AI's contribution to the UK economy, for instance, is estimated to the tune of US$ 814 billion by the period 2035, which is expected to improve the annual growth rate of GVA from 2.5 percent to 3.9 percent.

Policy Framework: Way Forward

Reality Checks

AI is expected to transform India's economic landscape from agriculture to manufacturing and services. It is thus an opportune time to devise a strategic plan and formulate a national policy framework on AI to enable, and perhaps even, catalyze the transformation. This would entail a closer examination of the existing challenges in the smooth diffusion of AI.

As mentioned before, the GoI initiated a discussion paper on AI in 2018. According to Niti Aayog (2018), the overarching theme *#AIforAll* aims at enhancing and empowering human capabilities to address the challenges of access, affordability, shortage, and inconsistency of skilled expertise; implementation of AI initiatives to evolve scalable solutions for emerging economies; tackling application, research, development, and technology-based challenges; and enabling collaborations and partnerships for greater good and prosperity.

However, there lay some underlining challenges in its deployment. These include the lack of broad-based expertise in AI research and applications, absence of enabling ecosystems – access to intelligent data, high resource cost, low awareness on AI adoption, privacy and security issues, lack of formal regulations around data flow and reliability and absence of collaborative approach on adoption and application of AI (Niti Aayog, 2018).

The authors have delineated these challenges in the Indian context against some of the defining benchmarks of AI which are standardization; knowledge transfer; ethics, accountability, traceability, certification; research, innovation and entrepreneurship.

Challenges

1. **Standardization:** Standards are the basis for industrial-scale use of AI. They pertain to the entire AI pipeline – from data to model creation, model validation, inter-operability to deployment and commerce. According to Marr (2017), while standards are required for each component of the pipeline, nothing is more crippling than the non-availability of data which can be used to train AI models. The GoI has also reinforced the need for data availability with adequate safeguard mechanisms in place for the effective deployment of AI systems.

    The challenge lies in the lack of appropriate and effective standardization policies in place. 'The most important challenge in India is to collect, validate, standardize, correlate, archive and distribute AI-relevant data and making it accessible to organizations, people and systems without compromising privacy and ethics...ensuring data security, protection,

privacy, and ethical use via enabling framework, both regulatory and technological' (GoI, 2018). Therefore, standardization is the key to the functionality and interoperability of AI platforms.

Some of the existing global initiatives in this area are noteworthy and worth studying while formulating a national plan of action on AI in India. For instance, according to a report of Tsinghua University (2018), China has underlined its standards and guidelines on AI under the 'New Generation Artificial Intelligence Development Plan' in the year 2017. Also, its 2018 white paper on AI highlighted the country's domestic standardization policy framework to set up an AI industry worth US$ 140 billion. Similarly, the United States of America (USA)'s American AI Initiative released a comprehensive plan on federal engagement in developing technical standards and related tools on AI, in the year 2019 (Federal Government of the USA, 2019).

2. **Knowledge transfer:** Transfer of knowledge and its management is essential for an effective understanding of AI. The literature has consistently emphasized the need to bridge the gap between ML and human learning through such information exchanges. For example, Torrey and Shavlik (2009) highlighted the techniques that enable knowledge transfer to represent progress towards making machine learning as efficient as human learning.

In India, the technical expertise needed for deployment of AI has been found out to be insufficient due to the limited training facilities and inadequate efforts in capacity building of the workforce. While digital and open learning platforms are promoted to enhance capacity building and public awareness on AI and the Internet of Things (IoT), the access, quality and authenticity of such online avenues remain a concern. Therefore, streamlining measures to promote their uniformity, standards, and outreach especially in remote areas, are needed. For instance, in the agriculture sector, the development of smart weather pattern tracking applications could be beneficial for the yield and production of crops. In such a case, the users and providers should have adequate access to IoT devices and appropriate knowledge of their functioning so that such an application can be beneficial in making correct predictions of the weather.

Various studies have also emphasized the skilling and reskilling component of the workforce. That is an important ingredient for India to ensure continuous absorption in AI deployed priority sectors. Therefore, specialized courses and academia-industry driven curriculum on AI, are need of the hour. The integration of AI-centric skills with the existing standards of the National Skill Qualification Framework (NSQF) is also crucial to

mitigate the demand and supply of skills mismatches in this field and improve domestic employment or job creation in the country.

3. **Ethics, Accountability, Traceability, Certification:** The effective deployment of AI underlines the need for transparency in the flow of information, data and algorithmic programming, data privacy, certification of the technology and traceability and accountability of users and owners. In other words, AI is governed by certain strict ethics concerning its use.

   In India, the issues of privacy and transparency of data, its storage and dissemination need to be properly addressed. The country needs an effective regulatory framework governing the collection, dissemination and use of data. The digital flow of information also carries the risk of security breaches and cybercrimes in the absence of adherence guidelines and an approved code of conduct. Therefore, the need of the hour is to have in place a robust AI ecosystem in India supported by an appropriate indigenous infrastructure for data storage and processing. At the same time, the local institutions can also upgrade their technology networks to optimize economies of scale. In other words, scalability must be undertaken on a high priority to ensure the enforcement of security-driven last-mile data connectivity.

   The GoI has proposed the setting up of a 'consortium of Ethics Councils' which would design guidelines on privacy, security, and ethics of AI. This would ultimately lead to the creation of a National AI Marketplace that would encourage discovery, innovation and reduce the time and cost involved in data collection.
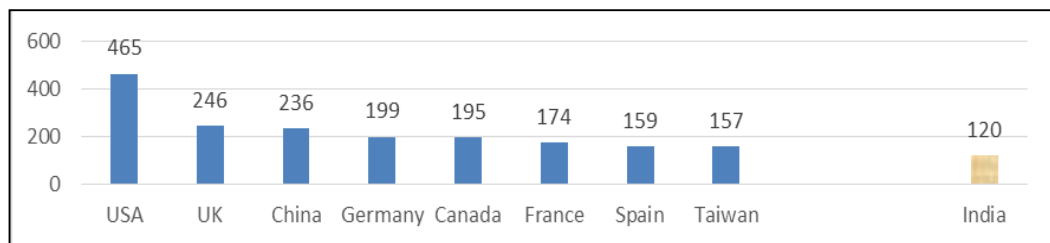
4. **Research, education, innovation, and entrepreneurship:** The emerging technology frontiers of AI invite advanced research and innovation on one hand and a thriving start-up industry on the other. The former refers to the provision of higher education centered on advanced AI learnings including applied algorithmic programming, digital ledger technology, data analytics, cyber-infrastructure, etc. It would also include interdisciplinary research in AI and investment-driven focused research and development (R&D) projects.

   The global initiatives in this field are worth emulating. For instance, countries like the USA and South Korea have targeted huge investments in AI-driven R&D. The former also has a national AI R&D Strategic Plan in place examining the critical areas of R&D that require government investments. Similarly, some of UK's private universities like Cambridge and Oxford are popularly known as centers of AI innovation, stimulating start-ups in this field. Its Alan Turing Institute or the National AI Centre (the national institute for data science)

encourages interdisciplinary solutions to real-world problems (Saran et.al., 2018). Similarly, in China, according to Robbins (2019), higher education universities have been receiving funding from their government to establish a dedicated Research School on AI within their campuses. Interestingly, the country has also partnered with various information technology companies to promote field-specific research and industrial leadership. Moreover, a technology park worth US$ 2.1 billion has also been set up in Beijing to facilitate AI-driven research.
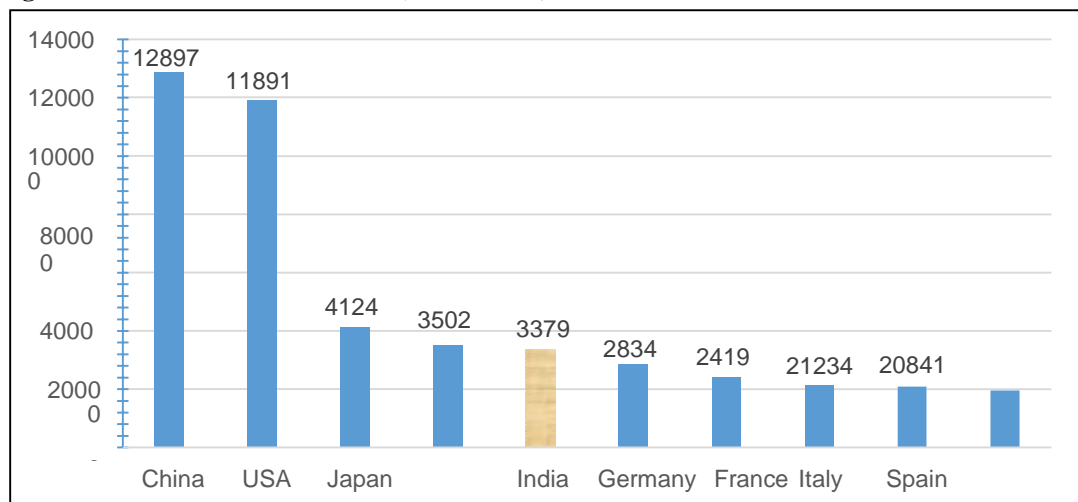
In India, on the contrary, AI-oriented research is still catching up and needs to be heavily invested in. Existing data reveals that research and innovation in the field are far below the existing potential the country has in the background of positive macro-economic fundamentals and a thriving technology market. Figures 1 and 2 reveal some of the statistics. According to the H-index (Figure 1), India has been globally ranked at the 17th position. Similarly, for the number of AI-centric research publications or citable research documents in AI (Figure 2), India is ranked behind China, the USA, Japan and the UK (figure 2).

Figure 1: H – Index for AI (1996 – 2018)

Source: Scimago Journal and Country Rank (SJR) County Rankings 2020

Figure 2: Citable Documents in AI (1996 – 2018)

Source: Scimago Journal and Country Rank (SJR) County Rankings 2020

The GoI has also flagged the limited academic research work being carried out in this field in the country. According to the GoI (2018), out of the 22,000 global doctorate scholars on AI, approximately 386 are in India. This is minuscule considering India's growing percentage of human capital, primarily youth. Additionally, it has also been reported that quality research work on AI is estimated to be among less than 50 researchers in the country primarily concentrated at national technology and science institutes.

One of the underlying reasons for such a non-satisfactory research performance lies in the lacking academia-government–industry collaborations. The lack of such engagements and partnerships restricts the growth of research, innovation, and entrepreneurship in the country. The GoI (2018) has also reinforced the need for an active engagement of all stakeholders to enable consensus-driven decisions. It is, therefore, imperative to leverage the unique and vibrant R&D ecosystem of India combining the strengths of government, academia, and the industry.

Another reason lies in the fact that India's tertiary education in AI is in nascent stages. Education and technological inclusion of individuals in a country are closely interconnected. According to Guilherme (2019), education allows individuals to become technologically included in a particular country, thereby becoming fit to join the labour market and contribute to its economic development. Therefore, the higher education universities and institutes of India must gear up to ensure that the learnings in AI are progressive, inclusive, skills-oriented and employment generating. There is a need to formulate a skills-oriented curriculum for higher learnings and specialization. Up-skilling and re-skilling of the workforce and university students can be undertaken through various training programs like the national mentoring program, decentralized content generation mechanisms and community-based learning models. Laboratories in AI, ML and Computational Thinking at universities can actively contribute towards capacity building, strengthening computational skills and predictive capabilities of students.

Finally, from a regulatory angle, research-driven innovation and activities must be streamlined with the help of a 'regulatory sandbox' environment and a robust intellectual property framework. As a success story, the former is already being implemented by the Government of Japan, where-in the country has AI-centric regulatory sandboxes providing certification and testing spaces for innovative AI solutions and curation of data (Saran et.al., 2018).

In the case of latter, the establishment of Intellectual Property Centres may perhaps bridge the existing gaps between AI developers, programmers, practitioners and

policymakers. The narrow-focused and stringent patent law regime could be replace with a more innovation-friendly IP law. Simultaneously, regulatory incentives especially to promote the growth of start-ups and MSMEs in this field, would be quite beneficial.

In other words, a robust policy regime that encourages quality research, new inventions and innovations as well as nurture entrepreneurial talent, is the need of the hour.

In a nutshell, a table (Table 1) is presented below in the form of a matrix that lists desired actions against each of the AI benchmarks specified above. Clearly, there is a considerable amount of good work that is ongoing in India and we present the suggestions in Table 1 to augment these efforts.

Table 1: A summary of desired actions against AI benchmarks

Benchmarks	Suggestive Measures to promote and realize the benefits of AI
Standardization	White Paper on AI standards and guidelines underlining standardized laws and regulations on AI; regulatory framework governing technical standards on AI; building a secure data ecosystem with the help of a national law/legislation governing data usage, privacy, protection and security and inoperability of AI platforms
Knowledge transfer	Policy guidelines underlining authenticity of content and services offered through online and open-source learning platforms; collaborative initiatives to enable creation and outreach of AI-driven applications, IoT in remotely accessible areas; Integration of skill requirements/demand with the supply of training sessions through NSQF; Provision of training, specialised courses through academia-industry linkages/collaborations; focused public discourses and deliberations to spread knowledge awareness on AI
Ethics, accountability, traceability, certification	Ethics Councils, Facilitation of data processing and storage architecture at a national scale through suitable funding model / PPP, certification authority to certify AI implementations and promote confidence and experimental modelling.
Research, innovation, and entrepreneurship	Strategic Plans on R&D funding; Specialised Research Centres on AI / Centres of Research Excellence / Think Tanks focusing on core technology research of AI at universities (provision of funding and specific grants to support such initiatives); academia-government-industry collaborations or partnership initiatives; active engagement and involvement of all stakeholders from the academic community and industry in the policy formulation process.

	Regulatory / innovation sandboxes, Centres of AI Innovation at universities, IP facilitation Centres. PPP entrepreneurship learning platforms; regulatory incentives, investor-friendly policies encouraging the growth of start-ups and SMEs; industry-driven incubation facilities on AI for startups to encourage entrepreneurship.
Education	Specialized courses (such as credit-bearing open online courses) and certifications on AI for students; academia-industry collaboration driven curriculum design for better employment opportunities; skills development and training facilitation to faculty and graduate students on use-based AI programs; institutionalization of special fellowships on AI to promote advanced education and research; formation of a global expert pool for core research on AI-supported by special financial grants and subsidies; university-industry partnership-driven Centres of Transformational AI in sectors like health, education, agriculture, smart mobility, etc.

Policy Framework

The previous section highlights the challenges and the possible measures to ensure the effective contribution of AI in India's growth and development. This must be governed by a national policy framework. The Policy must be holistic and supported by a visionary roadmap for its implementation. Such a policy framework should be able to examine the issues, challenges and delineate doable measures to resolve them. This could ensure the effective and seamless deployment of AI across different verticals and streams.

The guiding principles for a comprehensive policy framework on AI are the following:

a) AI should benefit people by driving inclusive growth, sustainable development, and well-being.

b) AI systems should be designed in a way that respects the rule of law, human rights, democratic values, and diversity, and they should include appropriate safeguards – for example, enabling human intervention where necessary.

c) There should be transparency and responsible disclosure around such systems to ensure that people understand AI-based outcomes, can audit them, and if required, challenge them.

d) AI systems must function in a robust, secure and safe way throughout their life cycles and potential risks should be continually assessed and managed.

e) AI systems should be certifiable in the same way that many other systems are certified (for example, setting up of certification institutions for like on the lines of ISI).

Conclusion

AI has immense potential to spearhead a technology revolution world-wide. Recognizing the positive potential benefits of an AI-economy, several countries like the USA, Japan, the European Union (EU), South Korea, the UK, etc have executed national strategies, plans, and focused policies to facilitate AI's smooth deployment and application in their respective economies.

It is an apt time for India to leverage this potential and bridge the gap between human learning and AI. As the Hon'ble Prime Minister of India has cited, "There should not be a debate on the dangers of artificial intelligence, but there should debate as to when the robot will be smarter than the human. There should be a debate as to how a bridge can be made between artificial intelligence and human intentions." A beginning has already been made in this direction with India becoming a founding member of global alliance on AI.

The need of the hour is to have in place a robust national policy on AI and a visionary roadmap for its timely implementation. This must include the scope of collaborative initiatives between the academia-industry and academia-government; interdisciplinary studies; measures to empower human capital to address the challenges of accessibility, affordability, and quality of the skilled workforce; regulatory incentives and sustained funding mechanisms to encourage research, innovation, entrepreneurship and quality of life in the country.

Declaration

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