CHINA'S A.I. DEVELOPMENT PLAN

A systemic analysis of the design of the State Council of China's Next Generation Artificial Intelligence Development Plan and its implications for India

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Note from the author

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Deeply, but perhaps not coincidentally, nested in a background comprising of a portrait of the Great Wall of China, classical books on communist ideologies, humanizing family pictures and the starry national flag of the People's Republic of China during his 2018 new year speech, President Xi Jinping had two quaint little books in his bookshelf on a not so quaint. The technology in picture is Artificial Intelligence and the two books on President Xi's shelves were 'The Master Algorithm: How the Quest for the Ultimate Learning Machine Will Remake Our World' by Pedro Domingos and Brett King's 'Augmented: Life in the Smart Lane'.

In an interview to Quartz magazine (Huang, 2018), when asked how he felt about his book landing on the shelves of one of the most powerful men in the world, Domingos described it as "both exciting and scary". To be honest, that is how most China watchers and Artificial Intelligence (A.I.) enthusiasts feel about China's rise as an A.I. superpower as well.

While in India, most of the discussion surrounding China is categorically placed under the labels of foreign policy, trade deficits, economic development or one of their close corollaries, there exists little understanding of China's socio-technical regime that is enabling it to become a technological superpower.

This causes two fundamental challenges- the first, is that it scares us. It makes us fear the unknown and causes policy makers to react spontaneously and defensively. The second is the loss of an opportunity – the opportunity to gain from the development and deployment of alternative technological sources in the international arena and learn from successful experiences.

The primary motivation for conducting this research and writing this report is precisely to counter these two challenges. The report, while focussed on the design of China's Artificial Intelligence policy, gives a sneak peek into how it is building an innovation ecosystem surrounding such new technologies and provides context for Indian policy makers to respond to the development of this paradigm technology in its neighbourhood.

As we took the onus to dive deep into understanding the key principles of China's Artificial Intelligence policy, the nature of the task demanded us of making sense of China and AI – each of which was an arduous task in itself. And as with all exciting things, the landscape surrounding China and AI kept moving at breakneck speeds – our job was often to make sense of an ever changing puzzle. The day we completed our first draft, when we thought we had finally mapped all the key points there were to note, the Beijing Municipal Science & Technology Commission announced a mammoth 30 billion yuan fund for research in high end technological science, including subjects such as brain cognition and quantum computing, introducing new players and targeting new areas. Hence, what this report does not do is provide an updated list of major events, funds and players shaping China's Artificial Intelligence race. What it does do is study the immensely well designed structure of innovation ecosystem surrounding A.I. that is allowing China to become an A.I. superpower and to that goal we quote examples, policy statements and economic principles in innovation economics liberally.

Through the reading of this text, we hope that policy makers, businesses and researchers in India and around the world can dive one level deeper and understand the thought process behind the State Council's Next Generation Artificial Development Plan.

Some people have been especially instrumental in building this report. I would like to thank Ayushi Jha and Kazim Rizvi for their support and essential feedback in the entire process.

Comments and discussions are very welcome and I strongly request the reader to please share any thoughts and suggestions at bhatia_ravish@yahoo.com or on Twitter at @RavBhatia.

I hope the report makes for an interesting reading.

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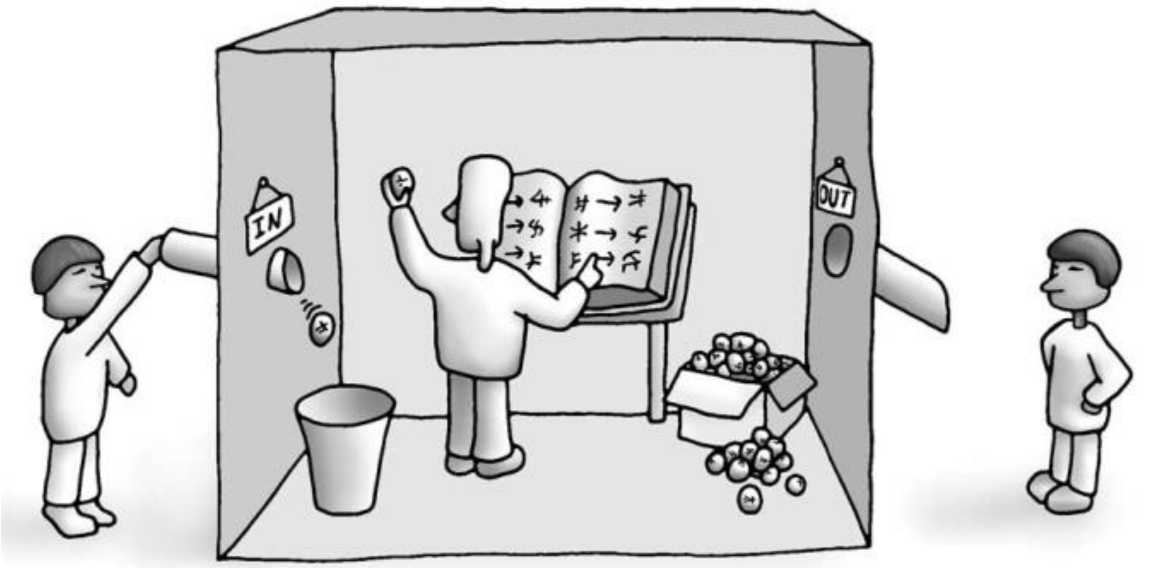
What are the key characteristics that define China's top down system of innovation?

The Chinese State Argument

Chapter 1: The Chinese State Argument

Introduction: What do we mean by the 'Chinese State Argument'?

In 1980s the philosopher John Searle came up with the Chinese Room Argument[1] , one of the most famous thought experiments often discussed in the context of Artificial Intelligence (A.I) and machine-human interaction. It begins with a hypothetical premise that assumes that "A.I research has been successful in creating a computer program that understands Chinese." The experiment then builds upon this hypothesis and goes on further to challenge the functionalist approach to understanding machine intelligence and what constitute a strong AI



Fast forward almost three decades, and things have changed. Two things in particular – first, the lexical semantics used in international discourse surrounding China, which once looked upon it as a mystical entity (perhaps the reason why Searle labelled his experiment as the Chinese Room Argument and not the Spanish Room Argument), have drastically changed. Second, recent advances in Natural Language Processing (NLP) have meant that A.I researchers

[1] In the early 1980s, the American philosopher John Searle, in a critique of the adequacy of the Turing Test, came up with a widely credited and often fiercely argued thought experiment popularly known as the "Chinese Room Argument". As part of the experiment, he imagined himself to be in a room following a computer program that allowed him to translate and respond to Chinese characters that were slipped from under the door. Searle understood nothing of Chinese, yet was able to produce a string of Chinese characters, fooling those outside the door into thinking that there was a Chinese speaker inside the room. In this manner, he questions the Functional definition of Turing Test and thus envisages the epistemological claim that just because a computer is able to respond to inputs by implementing a program, it does not imply that the computer has a cognitive state (understanding Chinese). This makes the argument one of the most often quoted thought experiments in debates pertaining to cognitive sciences, the definition of Artificial General Intelligence and what makes for Strong AI and Weak AI.

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have actually come extremely close to making Searle's hypothetical premise a not so distant reality. In fact, many of these recent strides in development of advanced NLP algorithms have been made in China, in Chinese. For example, LingoChamp (Liulishuo), a unique Chinese technology firm, launched in 2012, provides a personalized adaptive language learning experience to its over 50 million registered Chinese users by using advanced A.I-N.LP algorithms.

And so it is very clear that China has come a long way since the time Searle proposed the Chinese Room Argument. If anything, it would appear that it is at the forefront of responding to the complex challenges surrounding the development of complex new technologies in our age – many of which first germinated in the west, but have been incubated and fostered in China. As a country trying to 'catch-up' with the west, how did it manage to jump to the front and achieve such a high degree of technological advancement?

The response to that question is what this report describes as the 'Chinese State Argument', a reference to the top-down open and coordinated innovation ecology, supported and lead by the Chinese state in what can be described in economic terms as a 'National Systems of Innovation Approach'.

The basic framework: A National System of Innovation approach

The idea of taking a national innovation systems approach to the development and diffusion of technologies was first discussed in the middle of 1980s – the same time Searle formulated the Chinese Room Argument and also the same time when economists began looking at innovation and the development of new technologies from an economic framework extending much beyond the Solowian black box of 'technical change'. The approach "serendipitously intertwines(d) institutions and economic actors" (Narula, 2002) and despite some early resistance from World Bank and IMF, it has frequently begun to be acknowledged as concept in OECD and EU countries and more recently it has also begun to be frequently used in vocabulary by the US Academy of Sciences (Lundvall, Johnson, Andersen, & Dalum, 2002). Several studies in the early 1990s delved into the design of such national innovation systems (Freeman, 1995) (Lundvall B.-A. , 1992) (Nelson, National Innovation Systems. A Comparative Analysis, 1993). However the practical implementation of such an approach is being distinctly observed today, especially in China.

Technological transitions, which are a result of innovation ecosystems constructed at a macro level, involve not just changes in the primarily deployed technology but also in user practices, regulations, industrial networks and infrastructure. Frank W. Geels taking a multi-level perspective on such transitions empirically illustrates that socio-technical evolution is a process of

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unfolding and reconfiguration that involves three key mechanisms: niche-accumulation, technological add-ons and hybridisation (Geels, 2002). For this to take place, multiple stakeholders require interaction with each other (see Figure below). In the case of China, the intensity of such an interaction is amplified.

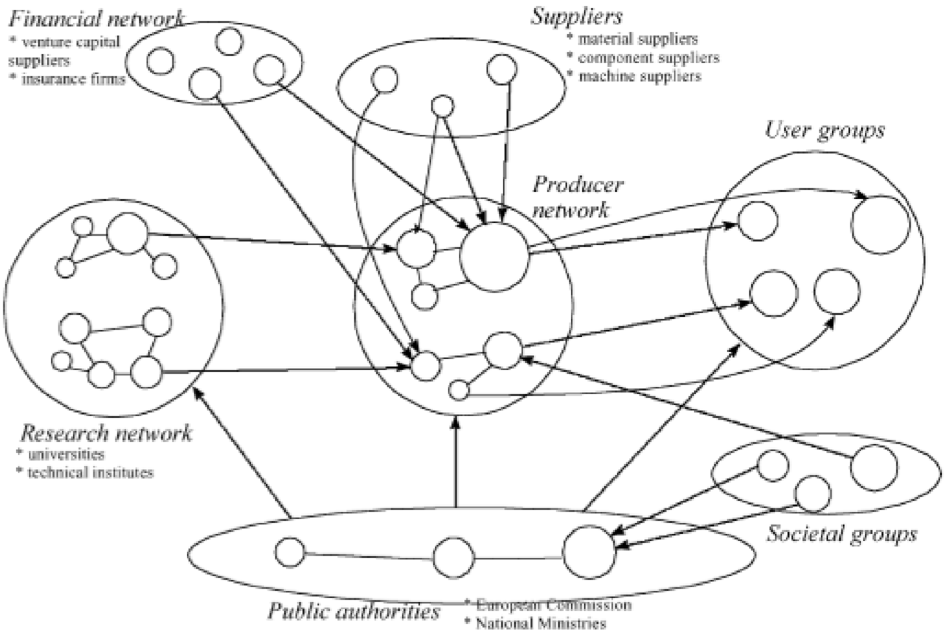

Figure: Multi-actor network in sociotechnical regimes (Geels, 2002)

This report analyses China's Next Generation Artificial Intelligence Development Plan from this perspective and argues for the rise of China as an A.I superpower based on this theoretical framework. But before delving into the how China is advancing its A.I goals, it would be important to understand how this coordinated top down ecosystem works. To do that, let us take an example.

Tsinghua Holdings Corp., Ltd. is a wholly owned subsidiary of Tsinghua University, one of China's leading university focussing on STEM courses and often referred to as the 'MIT of China'. Tsinghua Holdings, controls a 51% stake in Tsinghua Unigroup, which owns multiple subsidiaries that designs, develop, and markets wireless systems-on-chip and radio-frequency semiconductors for cellular, connectivity, and broadcast applications.

The remaining 49% stake is owned by Beijing Jiankun Investment Group, an asset management firm led by Zhao Weiguo, who was described by the Forbes magazine as the "Man Spearheading China's Chip Ambition" and is also the Deputy Director General of the "China High-End Chip Alliance". Tsinghua Unigroup in turn is partly funded to the tune of $1.6 billion by China's National Integrated Circuit Investment Fund (National IC Fund). In 2015, Tsinghua Unigroup made a $23 billion bid for Micron Technologies, a US based world leader in memory chip manufacturing (the deal was scraped by the US

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Committee on Foreign Investments later) and continues to invest in the strategic IC industries. Additionally, there is the Chinese American Semiconductor Professional Association (CASPA) which holds dozens of events per year in China and Silicon Valley aimed at recruiting foreign talent and overseas Chinese students who were trained in the west and gained experience in Silicon Valley (For 2017, the published schedule includes 4 conferences, 4 tradeshows, 4 workshops, 3 career development events, 3 international trips to China and 6 members networking events).

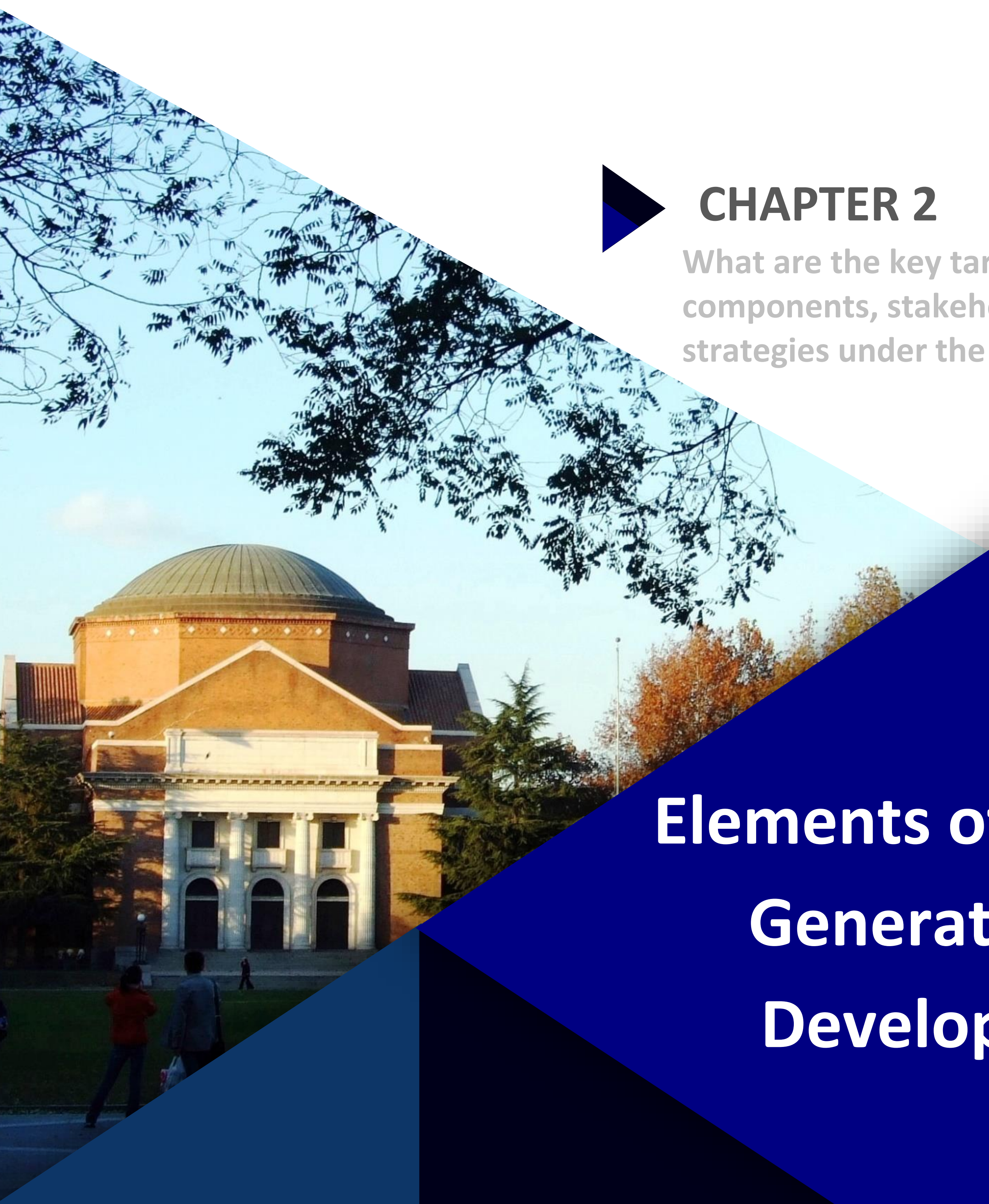
What we see in the above example is a coordinated action combining 3 key strategies – 1) indigenous scientific research and human capital from universities, 2) access to strategic foreign technologies through state backed capital and 3) institutional investment vehicles strategically investing to support not just domestic product innovation but also process innovation in the deployment of new technologies.

The creation of such an ecosystem in China, where multiple stakeholders work as cogwheels moving in the same direction, implies that China is better able to coordinate its actions to achieve the targets it sets out for itself. Some of the successful areas where such an approach has worked include technologies such as the High Speed Rail while some sectors where such an approach has worked but created some complications are those like the solar industry.

The top down nature of Chinese innovation ecosystem implies that it can push the supply of new technologies and expect the demand generation for these new technologies to follow. While the drawbacks of such an approach are severe, they are not the result of having a national system of innovation. This is to emphasize that not every system of innovation needs to be top-down, but for the development and advancement of large scale technological development, the existence of a national ecosystem is essential. China has successfully managed to come up with one.

The understanding of such an approach is essential to fully comprehend the design and the making of the Chinese Artificial Intelligence policy. It is also an important intellectual exercise that could be beneficial for policy makers in other emerging economies trying to come up with similar policy frameworks.

We now deep dive into the structure and design of the Next Generation Artificial Intelligence Development Plan.



CHAPTER 2

What are the key targets, components, stakeholders and strategies under the plan?

Elements of Next Generation AI Development Plan

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Chapter 2: Key elements of Next Generation AI Development Plan

China's tryst with A.I

Officially, "Artificial Intelligence" made its first appearance during the fifth session of the 12th National People's Congress in China Premier's work report in March 2017 and in July 2017, the State Council published the Next Generation Artificial Intelligence Development Plan (hereinafter referred to as the AI Development Plan) which hopes to inject a "new kinetic energy into China's economic development".

Advanced by a rising sense of techno-nationalism, combined with well-articulated state policies and growing human capital backed by strong state funding China has managed to emerge as a storehouse in cutting-edge technological development and has quickly managed to become one of the front runners in the race to A.I along with the United States. A report by Goldman Sachs published in August 2017, titled 'China's Rise in Artificial Intelligence' estimated the construction of an "intelligent economy" and "intelligent society" in China by 2030. While this report emphasized the trends in the Chinese AI industry to be enabling "business innovations and industry transformations", another critical report released by Dr. Kai Fu Lee, founder of Sinovation Ventures and Paul Triolo, head of Global Technology Policy at the Eurasia Group built a slightly more nuanced argument, albeit in the same direction. The report stated that there were four waves of AI deployment – Internet AI, Business AI, Perception AI and Autonomous AI and that while China had surpassed the US in the first wave of AI deployment (Internet AI built on consumer data), it lagged the US in the deployment of AI in business industries due to lack of commercial data sets (Sinovation Ventures, Eurasia Group, 2018).

Regardless of what report one read, 2017 was a year China arrived on the global stage in AI – or to frame it better, 2017 was the year the world took notice of China's rise as an AI superpower competing with the west. The US-China Economic and Security Review Commission in its Annual Report released in November 2017, dedicated an entire chapter to China's 'High Tech Development' in advanced sectors such as computing, robotics and biotechnology. The opening paragraph of this chapter reads "China has laid out an ambitious whole-of-government plan to achieve dominance in advanced technology. This state-led approach utilizes government financing and regulations, high market access and investment barriers for foreign firms, overseas acquisitions and talent recruitment, and, in some cases, industrial espionage to create globally competitive firms"

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This **“whole of government” approach** is what this report deals with. The first section of this chapter provides a summary and accompanying analysis of the design of the State Council’s Next Generation Artificial Intelligence Development Plan and the following sections take a deep dive into important aspects of the plan such as research and development, civil-military technological fusion, development of highly skilled human capital for A.I industries, approach to technology transfers from western countries and more.

Section 2.1: Principles, targets and focus areas under the Next Generation Artificial Intelligence Development Plan

The Next Generation Artificial Development Plan (新一代人工智能发展规划), hereafter referred to as “the plan” or the “AI plan” begins by painting a picture of the ‘strategic situation’ (战略态势). It calls AI as the “focus of international competition” (“人工智能成为国际竞争的新焦点”) and unapologetically announces its intention to “firmly seize the strategic initiative in the new stage of international competition in AI development”. Two key points mentioned as part of the **strategic situation** in the plan are relevant to this discussion. They are:

- The plan takes cognizance of the fact that there is a “gap between China’s overall levels of development in A.I relative to that of developed countries”. In this manner it unapologetically accepts China’s core deficiencies in original theoretical research and development of high end products such as chips. The targets set out and the approach adopted in the later stages of the plan is based on this core deficiency.

- The plan recognises the level of China’s absorptive capacity for new technologies and frames the discourse on the basis of the foundations created by previous science and technology development programs in the country, especially the Internet Plus programme and the AI Three- Year Activities and Implementation Program. In doing so, it is mindful of the country’s present capabilities, which is an important consideration for policy makers to have. For example: India has a high absorptive capacity for IT related industries such as A.I but it has little tacit knowledge base for the implementation of high end intelligent manufacturing. The plan represents a level of continuity from the previous technological plans that precede it and sets the principles and targets accordingly.

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There are **four basic principles** highlighted under the Next Generation Artificial Intelligence Development Plan . They are:

1. technology led explorations to accelerate the construction of a first-mover advantage;
2. formulation of a targeted systems strategy;
3. adherence to the rules of the market orientation for application use cases and;
4. advocating the concept of open source sharing.

However, one of the most important things that the Next Generation AI Development Plan explicitly lays out is the construction of an “open and coordinated AI technology innovation system”. Here it is important to stress that while discussions surrounding innovation in the West often mention ‘open innovation systems’, as popularised by Henry Chesbrough, the faculty director at the Center for Open Innovation at the Hass School of Business, the presence of the word ‘coordinated’ in the official Chinese policy document makes the AI Development Plan unique and different from those undertaken by its western counterparts. It also provides a good starting point for understanding how the process of such technological development is undertaken in China.

The plan undertakes to “Fully give play to the advantages of the socialist system to concentrate forces to do major undertakings, promote the planning and layout of projects, bases, and a talent pool, organically link already-deployed major projects and new missions, continue current urgent needs and long-term development echelons, construct innovation capacity, create a collaborative force for institutional reforms and the policy environment.”

Such a coordinated innovation ecosystem is a result of an approach founded on opposing yet inter-related concepts of “indigenous innovation” and “re-invention of foreign technologies” and is very much path dependent on the Chinese economic experiences. It is designed and closely connected to previous national technological enhancement programs such as the National Medium- and Long-Term Science and Technology Development Plan Outline (2006-2020) (MLP), the State Council Decision on Accelerating and Cultivating the Development of Strategic Emerging Industries (SEI Decision), and, more recently, the Notice on Issuing “Made in China 2025”. It also works in conjunction with and is complementary to the Robotics Five-year Plan, Internet Plus and the Industry Technology Innovation Capacity Development Plan (2016-2020).

By means of such the coordinated action described in the previous sections, the plan sets out to **achieve the targets highlighted in Table 2.1.**

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Table 2.1: Key targets under Next Generation Artificial Intelligence Development Plan

Year	Key Objectives	Targeted Value of Industry
2020	Develop the overall technology and application of AI in step with globally advanced levels (play catch-up) and ensure that the initial AI technology standards, service systems and industrial ecological value chains are in place in China.	Exceed 150 Billion RMB for core AI industries and exceed 1 trillion RMB for related industries.
2025	Achieve major breakthrough in basic theories for AI so that AI becomes the main force driving Chinese industrial upgradation.	Exceed 400 Billion RMB for core AI industries and exceed 5 trillion RMB for related industries.
2030	Form a mature new generation AI theory to achieve major breakthroughs in brain-inspired intelligence, autonomous intelligence, hybrid intelligence and swarm intelligence and intelligently apply AI technology to high end industrial chains.	Exceed 1 trillion RMB for core AI industries and exceed 10 trillion RMB for related industries.

As is evidenced in most literature surrounding evolutionary economic theory, gradualism as a process during such technological transitions allows for a high degree of variation, selection and retention. It is followed by a steady diffusion of new technologies into the practices, organizational structures and routines of firms. The 'Strategic Objectives' listed as part of the Plan take such a gradual approach.

Such a gradual approach is actually quite typical of Chinese policy making as has been seen in history through the gradual reform and opening up period. In a paper by Henning and Lu titled "Political Foundation of Chinese Style Gradualism: A Paradox of Too Strong Private Interests?", the authors seek to analyse why modern China follows a gradual approach and from a societal perspective, when is gradual approach better than big bang approaches to policy change (Henning & Lu, 2000). They argue that in China, an equilibrium exists in the balance of power between the state and the society which needs to be maintained through gradual economic policies and that given the high uncertainty associated with big bang reforms, political motivations for Chinese policy makers dictate a gradual approach as it limits the struggles between the state and the society (and influential individuals). Another element however can

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be introduced into this model– that of the Party. In the context of China's AI policy, that would be explain the rising techno-nationalism in the country and the setting of such urgent targets.

The timelines set between these targets are extremely small and aim at more than doubling (approximately 2.5 times) the scale by value of the core AI industry every 5 years. This is descriptive of a parallel sense of geo-political urgency that is by definition antithetical to the gradual approach taken by economies. It is reflective of the State Council's objectives to not give up on building China's "first-mover advantage in the development of AI".

Hence China's AI strategy can be described as a hybrid of gradualism and urgent reform. While the process of design of technological transition is structurally similar to that of more gradual approaches, the targets are extremely ambitious and the time span to achieve them have been shrunk in a very short duration (but still not a big bang approach).

The setting of such techno-nationalistic targets that are based on the fear of missing out on first mover advantages in the field of AI has some drawbacks as well. It could lead to the flow of capital and investments in areas and firms that have little returns and lead to a high levels of indebtedness. The Chinese policy makers in that case would rely on and hope that the combined macro returns of such investments to be positive.

Going back to the reasons for gradualism provided by Henning and Lu, it is important to maintain social stability in the society, especially in the wake of technical disruptions. The Chinese AI Development Plan takes that into consideration and aims to counter such challenges arising because of the 'urgency in its gradual approach' through a mechanism that it describes as "Public Opinion Guidance". The final section of the plan addresses this topic. It aims is to "fully use all kinds of traditional media and new media to quickly propagate new progress and new achievements in AI, to let the healthy development of AI become a consensus in all of society, and muster the vigour of all of society to participate in and support the development of AI. Conduct timely public opinion guidance, and respond even better to social, theoretical, and legal challenges that may be brought about by the development of AI".

To do this, the plan sets out 5 key 'Focus Tasks' with subtasks outlined in each. These tasks are:

1. Build open and coordinated AI science and technology innovation system
    a. Establish basic theory systems for a new generation AI
    b. Build a next generation AI key general technology system
    c. Coordinate the layout of AI innovation platforms
    d. Accelerate the training and gathering of high end AI talent

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2. Fostering a high end, highly efficient smart economy
    a. Forcefully develop new AI industries
    b. Accelerate and promote the upgradation of industrial intelligentization
    c. Forcefully develop smart enterprises
    d. Create AI Innovation heights
3. Construct a safe and convenient intelligent society
    a. Develop convenient and efficient intelligent services
    b. Promote the intelligentization of social governance
    c. Use AI to enhance public safety and security capabilities
    d. Promote social interaction and mutual trust
    e. Strengthen military-civil integration in the AI domain
    f. Build a safe and efficient intelligent infrastructure system
    g. Plan a new generation of AI major science and technology projects

The following sections, while diving deeper into the most critical strategies of building an innovation ecosystem, take into account the above mentioned focus tasks and also analyse the key policy actions undertaken by key stakeholders in that regard.

Section 2.2: The R of R&D

Why it is not so bad to be a laggard in early scientific research?

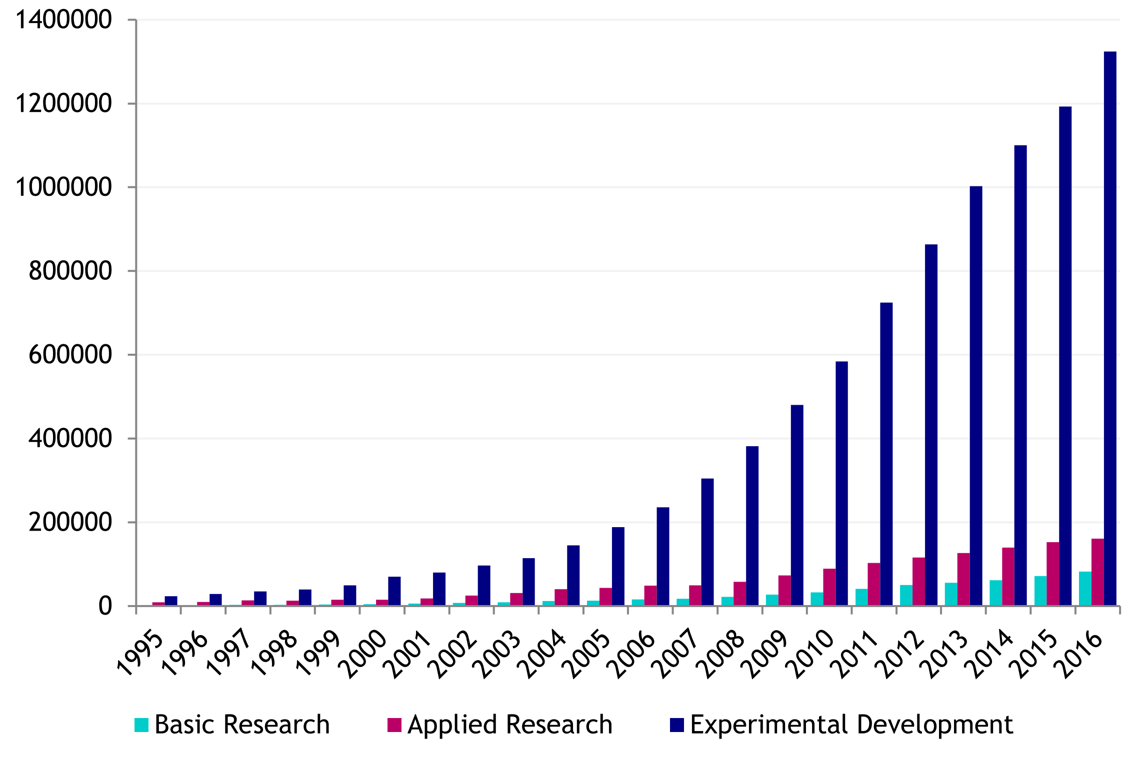
The early scientific research for Artificial Intelligence and cognitive systems originated in the United States. It was first proposed by researchers at Dartmouth College in 1956 and was followed by decades of theoretical and scientific research in fields such as cognitive reasoning, machine learning, natural language processing and robotics making the US a leader in research in AI and allied fields. However, as we see in a leader-follower model of innovation, in a perfect information system the technological advancements made by a leader become available to the follower with some delay. The first mover advantages through basic scientific research that were enjoyed by the US in development of AI technology (that has not been completely commercialized yet) is being utilized by the lateral entry of Chinese entities today.

Stiglitz (2015) notes:

"It is the non-convexities in learning, not in production, which play the central role in our analysis; in effect, it does not pay the laggard countries to pay the initial costs of catching up, given that they eventually will benefit from the leading countries' technologies as knowledge seeps down. This not only enables us to establish a growth equilibrium with non-convergence, but the nonconvexity remains relevant even if there are large numbers of countries (unlike, as we have seen, the Krugman model, where the disparities in income disappear in a “large” world.)”

By building upon the initial basic and fundamental research conducted in advanced developed economies such as the US, China has been able to play catch-up. In fact, this has been a general trend in China. As we can see from Graph 2.1 most research funding in China is focussed on experimental development and not applied or basic research.

Graph 2.1: Total national expenditure in R&D in RMB Million



Source: National Bureau of Statistics

‘Basic Research’ includes empirical or theoretical research aiming at obtaining new knowledge on the fundamental principles while ‘Applied Research’ refers to research focussed on exploring fundamental methods or approaches for a specific objective or target and is reflected in form of scientific papers, invention patents and fundamental models. Experimental development refers to systematic activities aimed at transferring practical knowledge gained from fundamental and basic research for development of new production processes, systems and services.

The results witnessed in Figure 2.1 are reflective of the general trends seen in China’s AI industry as well. Most research is focussed on the experimental

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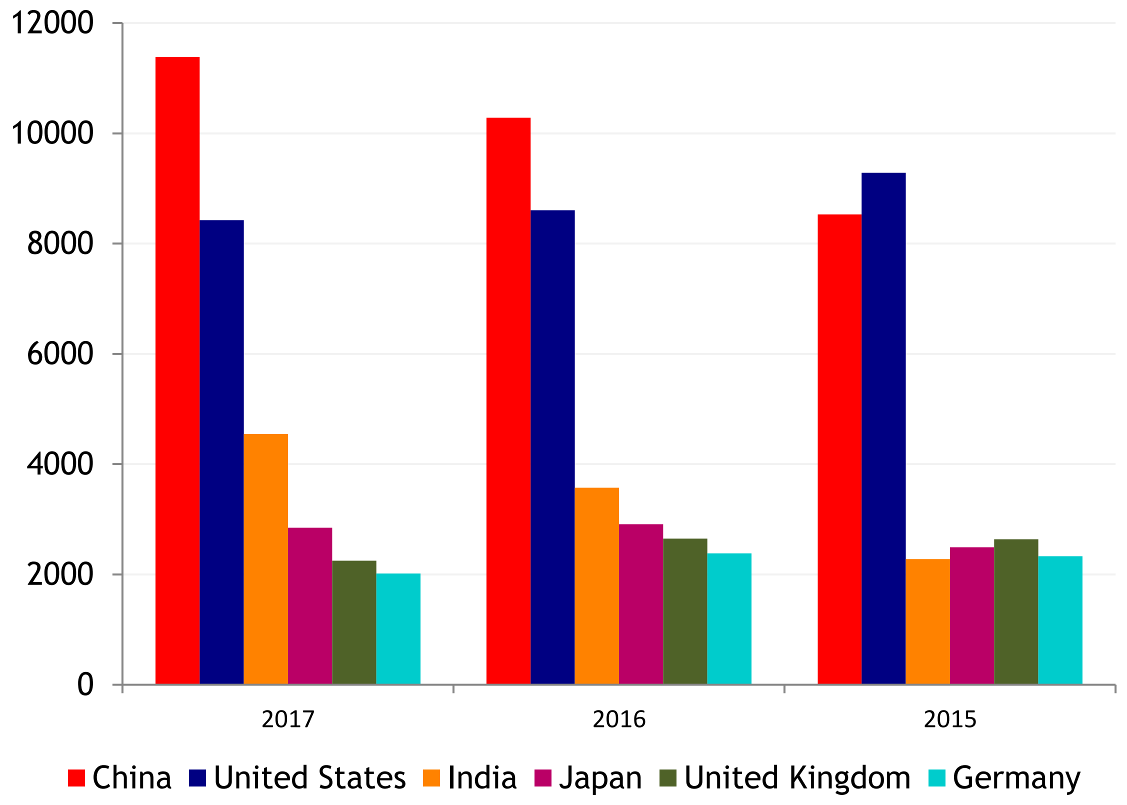
development of AI technology rather than basic research. The resulst of such a focus is reflected in Figure 2.2 and Figure 2.3.

As can be seen from Figure 2.2 the total number of citations of scholarly work in the domain of 'Artificial Intelligence' emanating from China crossed the number of citations from the United States in 2016. Additionaly, the National Artificial Intelligence Research And Development Strategic Plan (NAIRDSP) published in October 2016 by the National Science and Technology Council in the United States noted that the number of journal citations mentioning the words "deep learning" and "deep neural networks" originating from China overtook those originating from the US in 2014.

Figure 2.2: Number of research citations related to 'Artificial Intelligence'

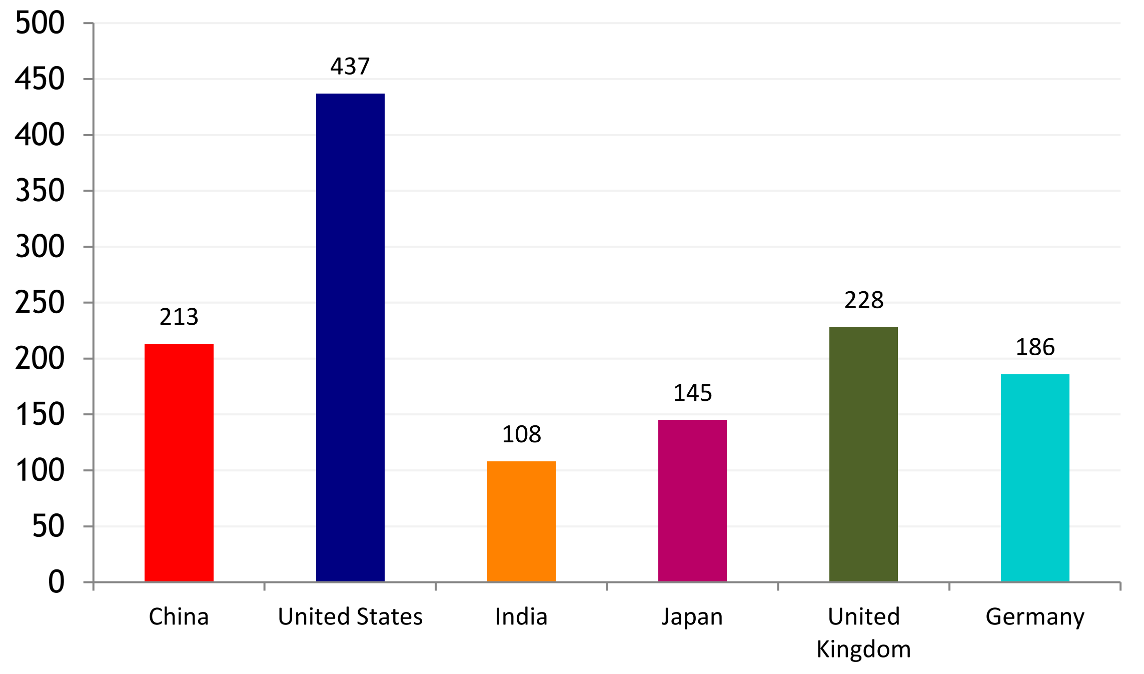


Source: Scimago Institutional Rankings

However, the quality of such research is not as high as that in the United States. As per the Scimago Institutional Rankings, for 2017, more than 70 percent of the citations in China were self-citations. This is also reflected in the H-index of such research work.

The h-index is an author-level metric that attempts to measure both the productivity and citation impact of the publications of a scientist or scholar. As shown in Figure 2.3, the United States leads China significantly in this metric, with the value of the metric for the United States being almost double as that for China.

Figure 2.3: H- Index (2016-2017) as a measure of productivity and citation impact of work on/ related to 'Artifical Intelligence'



Source: Scimago Institutional Rankings

The AI Development Plan recognizes this deficiency and aims to respond to that. As per the Strategic Objectives outlined in the Plan, the second target aims for China to “achieve major breakthroughs in basic theories for AI, such that some technologies and applications achieve a world-leading level and AI becomes the main driving force for China’s industrial upgrading and economic transformation”. For the same, China has launched multiple state led initatives in scienftici fields affecting A.I capabilities such as the China Brain Project ((中国脑计划) in 2015.

Note that the National Basic Science Development Five Year Plan (国家基础研究发展“十二五”专项规划) released in 2011 also emphasized these issues and the need to focus on domestic research, but little has changed in the ratio of funds dedicated to applied and basic research since then.

Here it is important to mention that state led industry organizations in China also play a significant role in coordinating research work. The Chinese Association for Artificial Intelligence (CAAI; 中国人工智能学会), established in 1981, is the national level professional society focussed on scientific fields of research related to AI in China and comprises of both domestic as well as foreign

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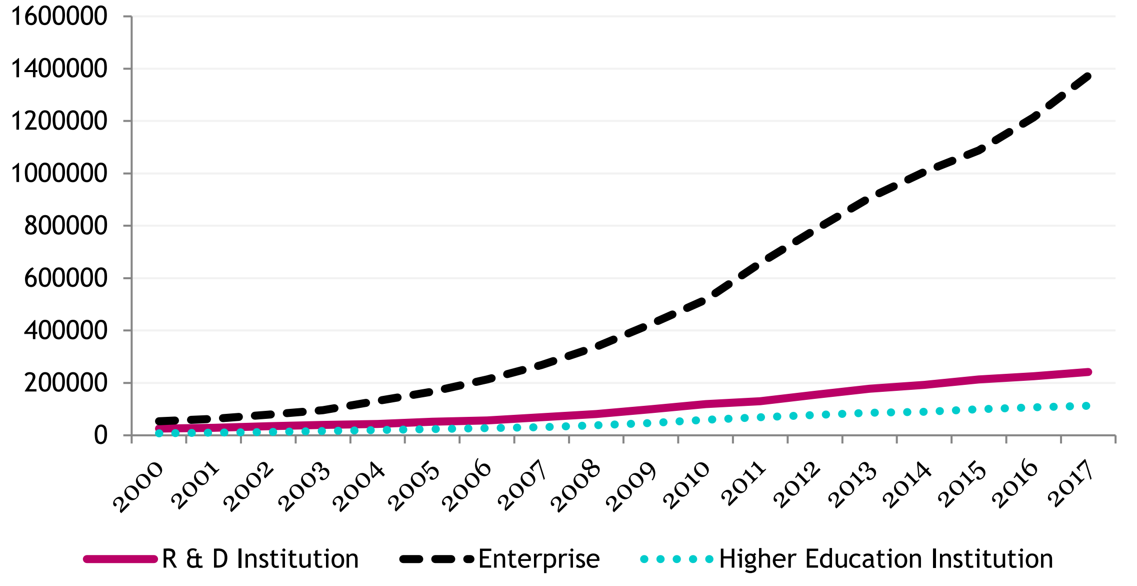
experts and is responsible for promoting academic exchanges and publishing latest research related to AI in China. It has more than 40 subcommittees focussed on different fields within AI and comprise of members from academia and scientists, personnel with military background and leading technology firms. Another organization that plays a critical role in development of AI related algorithms is the China Robot Industry Alliance (CRIA; 中国机器人产业联盟), a structurally similar non-profit alliance that serves as a cooperation platform between the industry, military and academia to advance the co-development of robotic technologies.

Figure 2.4: Total national expenditure in R&D in RMB Million



Source: National Bureau of Statistics

A very likely partner - the private sector

Even though the research emanating from China is moving forward with breakneck speeds, the research ecosystem in China is still relatively weak compared to that in the US. The quality of research conducted in US research institutions is significantly higher. For example, as per as report by Times Higher Education measuring the quality of AI research by Field Weighted Citation Impact, only one Chinese institution – the Institute of Automation of the Chinese Academy of Sciences scored above the world average of 1 (2.26) whereas leading US universities in fields of computer sciences such as the Massachusetts Institute of Technology scored 3.57 and Carengie Mellon University scored 2.53.

Nevertheless, it is receiving a transformative push through the close partnerships being formed between leading technological enterprises, which are

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the storehouse of massive datasets and leading Chinese universities, which are the storehouse of advanced theories and new scientific techniques (both domestically produced as well as acquired from outside). This is in line with the observation that most of the expenditure in R&D is by enterprises in China. Alibaba's massive data sets are set to achieve a major boost by its partnership , which was announced in March 2018, with Tsinghua University which is at the forefront of engineering in China. The joint partnership between Alibaba and Tsinghua would be in three key domains – human and environmental interactions, emotion recognition and multichannel recognition. Such partnerships by Chinese enterprises however, are not just limited to Chinese universities. OPPO, which already has partnerships with NYU, recently announced the setting up of the OPPO-Stanford Collaboration Lab in Silicon valley to complement its existing R&D centres in Beijing, Shenzhen and Japan.

Another key strategy being deployed is the internationalisation of R&D. Literature on R&D internationalisation points to two potential reasons for firms to internationalize their R&D – first, demand driven reasons, where firms shift their R&D facilities closer to their customer/suppliers and second, supply side factors where firms move, acquire or form alliances internationally to internalise new technological assets. However Narula, taking a system of innovation (SI) approach, argues that firms – ceteris paribus- tend to concentrate their R&D activities in home countries and only radical innovations or technological discontinuities require firms to move away from their SI to an alternative SI (Narula, 2002). Narula mentions the need for creating "durable linkages with the SI of a host location". He also notes the "Government funding agencies, suppliers, professors, private research teams and informal networks of like-minded researchers take considerable effort to create and once developed, have a low marginal cost of maintaining." Given the 'radical innovations' and 'technological discontinuities' in development of AI, Chinese firms such as Baidu and Tencent have set up their R&D facilities in Silicon Valley (so has Google in China).

Baidu's internationalization into Silicon Valley shifted its locus of scientific developments with the founding of the Baidu Silicon valley AI Lab (百度美国硅谷研发中心) in 2011. SVAIL in combination with its other two research labs, namely, the Beijing-based Baidu Big Data Lab (百度大数据实验室) and the Beijing Deep Learning Lab (百度深度学习实验室) have made extensive progress in various domains of AI.

Open research

The AI Development Plan lays special focus on building an open innovation ecosystem which implies that it would require the construction of an open

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research network as well. This factor is especially critical for the development of AI industry given the need for big data sets and access to critical components of complex algorithms that make innovation more accessible to all who wish to engage in it.

The plan describes the construction of 5 types of open knowledge sharing support platforms. They are:

1. AI Open-Source Hardware and Software Integrated Platforms to Establish big data and AI open-source software platforms, terminal, and cloud collaborative AI cloud service platforms.
2. Group Intelligent Service Platforms to group intelligent learning and automation systems, open environment cluster decision making ytstsems and group sharing economic service systems.
3. Hybrid Enhanced Intelligent Support Platforms that utilise supercomputing centres for complex cognitive science based systems, security platforms supporting security operations and testing platforms for human-machine joint driving technology.
4. Autonomous Unmanned System Support Platforms for supporting unmanned robots, vehicles and intelligent factory equipment.
5. AI Basic Data and Security Detection Platforms for constructing data oriented public libraries, standard data sets, cloud service platforms and security evaluation tools for AI algorithms.

Such efforts are essential in democratizing innovation and building innovation from the bottom up and are a positive push from the Chinese government.

Section 2.3: Military Civilian Technology Diffusion

Military as a key institution for the construction of new technologies

Strong institutions are often citied in economic theory as important for economic growth, but only recently the importance of institutions in technical advancement has begun to receive the necessary attention it deserves. The writings of (Dosi, Freeman, Nelson, Silverberg, & Soete, 1988) popularised this notion.

Military is one such institution in the innovation ecosystem that fosters technical change. Richard R. Nelson in his paper titled, "Institutions Supporting Technical Change in the United States" noted that the development of nuclear technology in the US was guided by payoffs to both power generation as well as military applications and most of the research funds for the development of such technology were provided by the federal government (Nelson, Institutions Supporting Technical Change in the United States, 1988). Similarly, most of the

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funding assigned to the development of computer technologies was initially aimed at military objectives while research for commercial applications of the same was left to private sector. (Flamm, 1985)

The *Next Generation Artificial Intelligence Development Plan* is distinctly cognizant of the role of such institutions. Among the key 'Focus Tasks' mentioned under it is to "Strengthen military-civilian integration in the AI domain" and the formation of an "all element, multi-field, high efficiency AI military-civilian integration pattern". This is in line with the Recommendation on Integrating Economic and Defense Developments[2] issued by the Central Military Committee and points to a move from "initial integration" to "deep integration" between civilian and military technologies. It promotes a not just coordinated but also compatible development of technologies and standards by tackling the 'four insufficients'[3] (四个不够): insufficient top-level planning; insufficient liberalization of military industry base; insufficient sharing of military resources and information; and insufficient 'spin-off' of defense technology.

Leendert van Bochoven, the NATO and European Defense leader heading IBM's efforts at NATO and EDA in a paper titled "Industry and Policy Partnerships in Disruptive Times" categorised the enablers of innovation in disruptive technologies under two key elements: innovation ecosystems and innovation platforms (Bochoven, 2016). He argued that rising technological complexities under budgetary pressures required undertaking of collaborative approaches to navigate the uncertainty associated with technological change (as described by Rosenberg). Examples of this approach include the Network and Information Sciences International Technology Alliance (ITA) between the UK Ministry of Defence (MOD), US Army Research Laboratory (ARL) and a consortium of more than 20 leading academic and industry partners and the DoD-DARPA led collaborative innovations software platform 'Innocentive@Work'.

Civil Military cooperation in China: More American than Soviet

The blueprint for Chinese Military Civilian Fusion in defence technology was published by the State Council in a document commonly known as the *Document 37* and several National MCF Demonstration bases have been formed which incubate and advance private enterprises and start-ups working on advanced technologies. For example, the Anhui Hefei High-tech Industry Development Zone (合肥高新技术产业开 发区) in Hefei, Anhui province is home to enterprises

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[2] http://www.xinhuanet.com/politics/2016-07/21/c_1119259282.htm
[3] https://jamestown.org/program/in-drive-for-tech-independence-xi-doubles-down-on-civil-military-fusion/

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producing “advanced technology products” advancing Military-Civilian Fusion to support “national scientific and technological innovation” (Levesque & Stokes, 2016). One of the companies based out of the base is iFlytek, a leading Chinese start-up with voice recognition and speech to text recognition capabilities which also serves as the leading unit in MIIT’s “Working Group on Technical Standards for Interactive Chinese Language Technology”.

The top-down nature of Chinese industrial policy design allows for the creation of such strong innovation ecosystem, as described by Bochoven, for the development of Artificial Intelligence. Drawing inspiration from a similar military-industry lead consortium in the west and the development of semiconductor and ICT technologies in Silicon Valley by the Defense Advanced Research Projects Agency and Department of Defense in the United States post WWII, China established the Central Commission for Integrated Military and Civilian Development (CCIMCD) in January 2017 with the aim of promoting dual use technologies and cutting costs in integrating existing civilian technologies into the People’s Liberation Army (PLA). Two months post the announcement of setting up of the coordinating body, China announced its smallest military budget increase in a near decade[4], suggesting increased reliance on civilian technologies to boost its military capabilities (and addressing the budgetary constraints that Bochoven noted). The state also decreased the regulatory costs associated with allowing private firms to get licenses for defense manufacturing[5] enabling private innovation for commercial application as was seen in the advent of the computer industry in the US (Flamm, 1985).

In way, it can be argued that the Chinese civil-military ecosystem resembles more that of the United States than of that of the erstwhile Soviet Union. Elsa Kania described it as “Chinese Military Innovation, with American Characteristics?”[6] Indeed, unlike the Soviet Union where the focus on development of new technologies was primarily for military and strategic purposes, research in military engineering in China, is motivated by a mix of both military and economic reasons – this is also one of the key reasons why an active participation is sought from public universities and not just from dedicated military research establishments.

In a Joint conference organized by the Chinese Academy of Engineering (CAE) and Tsinghua University in June 2017, the Dean of CAE, Zhou Ji announced, “AI will be the most important dual-use technology for the next ten years”[7]. One of the key methods undertaken to accomplish the “two-way transformation of AI

[4] https://thediplomat.com/2017/04/chinas-answer-to-the-us-military-industrial-complex/
[5] http://www.scmp.com/news/china/policies-politics/article/2088998/china-opens-military-contracts-worth-billions-yuan
[6] https://www.battlefieldsingularity.com/musings-1/chinese-military-innovation-with-american-characteristics
[7] http://news.sciencenet.cn/htmlnews/2017/6/380507.shtm

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technology" includes creating a "mechanisms to normalize communication and coordination among scientific research institutes, universities, enterprises and military industry units." Around the same time, Tsinghua University announced its plans to set up the Military-Civil Fusion National Defense Peak Technologies Laboratory aimed at creating dual use technology. Among other institutions, is the prominent university, Harbin Institute of Technology which was one of the only ten universities in the world to have designed, built and launched their own satellites. The university was also responsible for building the first intelligent chess playing computer and the first CMOS chip IC card in China[8] and houses the National Key Laboratory of Robotic Systems and Engineering, funded by the National Defense Science and Technology Key Laboratory Fund. Also, the 863 Intelligent Robotic Technology Topic Expert Committee (智能机器人技术主题) comprising of stakeholders of the industrial ecosystem such as the BIT Key Laboratory of Intelligent Control, HIT Institute of Robotics and Decision of Complex Systems, CAS SIA work closely with Hunan University in building intelligent robots running advanced machine learning algorithms.

The AI Development plan notes the Such a fusion and co-working between different institutions (private enterprises, universities and military) allows for the creation of a model ecosystem where returns to restrained resources are minimized and the knowledge sharing is both 'open' and 'coordinated'.

Section 2.4: Human intelligence behind AI - China attracting world talent

Fuelling creative destruction: a critical lack in productive capacity

As underlined in Schumpeterian theory, it is impossible to produce new products with old productive capacities. The process of 'creative destruction' requires the construction of new production processes and destruction of the old over a period of time. This challenge, perhaps, is most prominently attributed to the emergence of Fourth Industrial Revolution apropos which the debates regarding the necessity for upgradation of skill sets are most prominent.

A report by the People's Daily noted that "5 million artificial intelligence talents (are) urgently needed in China"[9] A LinkedIn report revealed that while there are some 1.9 million AI engineers worldwide, about one million reside in the US while China is home to just 50,000[10]. Even though there are several well

[8] http://www.scmp.com/lifestyle/technology/science-research/article/1767673/top-5-most-secretive-and-mysterious-research

[9] http://en.people.cn/n3/2017/0714/c90000-9241963.html

[10] https://business.linkedin.com/content/dam/me/business/zh-cn/talent-solutions/Event/july/lts-ai-report/%E9%A2%86%E8%8B%B1%E3%80%8A%E5%85%A8%E7%90%83AI%E9%A2%86%E5%9F%9F%E4%BA%BA%E6%89%8D%E6%8A%A5%E5%91%8A%E3%80%8B.pdf

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financed start-ups and a deeply engaging ecosystem, the human talent shortage faced by the industry is deeply concerning.

Building a strong local talent base

Hence, one of the focus tasks in the AI Development Plan under building an 'open and coordinated AI Science and Technology ecosystem' is to "accelerate the training and gathering of high end talent". Given the gap between the skillsets required and those domestically available, the AI Development Plan focusses on the introduction of international top scientists and high-level innovation teams in domains such as neural awareness, machine learning, automatic driving, intelligent robots and other areas.

A prominent emphasis has also been laid upon the construction of AI as an academic discipline as part of the plan and efforts to "increase the enrolment places for masters and PhDs in working in AI and related disciplines". In April 2018, China's Ministry of Education issued its AI Innovation Action Plan for Colleges and Universities to all public institutions of higher learning in China. The action plan report set out ambitious goals for its educational institutions in the development of AI as a scientific subject. It set out three key goals to be achieved by 2030:

- Fundamentally optimize the infrastructure of colleges and universities to spark technological innovations and adapt to the next generation of AI development by 2020;
- Develop achievements with a substantial global impact and deliver first-class theoretical research, innovative technologies, and applications by 2025;
- Make Chinese colleges and universities the world's leading AI innovation centres and a hotbed for AI talent by 2030;

The Ministry of Education also launched a five-year Artificial Intelligence (AI) talent training program[11] in April 2018 aimed at training at least 500 teachers and 5,000 students in artificial intelligence at top universities over the next five years. The program is based out of from Peking University and Sinovation Ventures, a leading technology investment firm headed by Taiwanese born Kai-Fu Lee, who once headed Google's operations in China, is part of the initiative.

Cross-industrial capabilities in construction of an AI ecosystem

Additionally, the plan proposes the establishment of a hundred categories called 'AI+X' – technologies and subjects such as mathematics, computer science, biology, physics, sociology and law which are closely interlinked to A.I and

[11] http://www.chinadaily.com.cn/m/beijing/zhongguancun/2018-04/04/content_35979394.htm

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essential for the development of complex cross-connected technologies. By 2020, the proposal aimed to the compilation of fifty world class teaching materials for undergraduate and graduate programs along with the development of 50 national high level open sources courses and establishment of 50 AI faculties, research institutions or interdisciplinary centres.

Such programs by the government have often been responded to by the private sector, both to win brownie points by the government and to advance their own capabilities. For example, Jack Ma in October 2017 announced that his company would set up DAMO Academy ("discovery, adventure, momentum and outlook") that would be devoted to conducting research on advanced technologies. Interestingly, it has been reported by the MIT Technology Review that the "Chinese name for the institute, 达摩, references Dharma, a legendary Indian monk said to have brought Buddhism to China in the fifth century." While Alibaba is already China's biggest R&D spender, its actions are very closely timed and synchronised with the Chinese government's policies.

Learning by attracting highly skilled foreign talent

The Thousand Talents Plan (referred to as "the Recruitment Program of Global Experts" before 2008) is a strategic channel aimed at directing foreign talent into China's domestic ecosystem comprising of 'National Key Innovation Projects', 'National Key Disciplines' and 'National Key Laboratories' for "scientific innovation, technological breakthrough, discipline construction, talent training and hi-tech industry development".

On February 27, 2018, the Municipal Government of Zhonguancun, a technology and business hub in the north western district of Beijing and also home to companies such as Lenovo announced "Measures to Deepen the Reform of Talent Management in Zhongguancun and Build an Internationally Competitive Mechanism for Bringing in and Hiring Talents" to facilitate of highly skilled personnel in STEM (Science, Technology, Engineering and Mathematics). The 'Zhitong Che' program in Zhonguancun (直通车 or *Zhítōng chē* literally translates to "through train") is a special program for speed tracking permanent residency applications of highly skilled foreign talent wishing to work in Zhonguancun district of Beijing.

Highly skilled foreign talents are being offered high salaries. For example, Nanjing University which opened one of the first AI institutes in China is offering AI researchers a base annual salary of US$60k, a housing subsidy of close to US$200k, and over US$300k in research funding as the starter package[12].

[12] https://syncedreview.com/2018/04/12/china-prepares-for-ai-talent-shortage/

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Jeffery Ding in a report titled "Deciphering China's AI Dream" published by the Future of Humanity Institute at the University of Oxford notes the movement of some famous names in the field of AI to China, "Andrew Chi-Chih Yao, a Turing Award winner who renounced US citizenship, is now researching "AI theory development." Additionally, Tim Byrnes, an Australian physicist is aiming to develop a quantum computer at NYU Shanghai, and Zhang Liang-jie, a former research staff member at IBM Watson, will investigate AI and virtual reality as chief scientist at enterprise software group Kingdee in Shenzhen."

The development of a high skilled talent pool to accompany the well-financed technology firms in a coordinated ecosystem will be biggest challenge to, and if done right then the biggest asset of, China's grand plans to lead the world in AI.

Section 2.5: Technology Transfers

Technology, for the purpose of this section, can broadly be defined as the knowledge and information required for practical, technical or scientific applications of Artificial Intelligence in the economy. Transfer of such technology could include voluntary, forced or directed exchange of such knowledge and information.

Technological development is an exogenous process and knowledge transfer is not free – there is a cost associated with it. This cost can be undertaken either by the State or by firms. China's industrial policies actively operate to reduce the costs for access and absorption of such technologies and provide resources to combine them with endogenous innovation.

Post the opening up of the Chinese economy, the first wave of technology transfers to China from more advanced economies was accomplished through cessions in production costs for manufacturing of products that were "Made in China" while the locus of design and technology was often located outside the boundaries of the country. The current wave of technology transfers is being led by research and development initiatives both in home as well as host (mostly US) countries. This is primarily accomplished through greenfield acquisitions of existing laboratories, setting up of new laboratories and partnership agreements. Such centres by nature of their design and objective focus mostly on experimental development and fundamental research. On the other hand joint scientific projects, scientific exchanges, sabbatical years and international flow of students greatly contribute to transfer of basic and fundamental research. These two streams of transfers are porous and often interact with and/or support each other.

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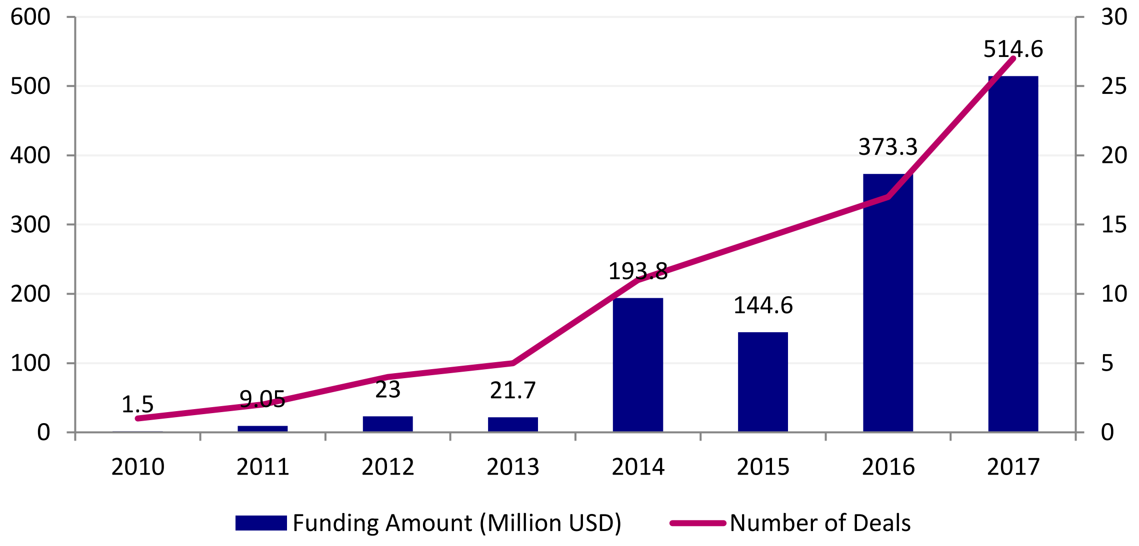
In the *Opinions on Encouraging Technology Introduction and Innovation and Promoting the Transformation of the Growth Mode in Foreign Trade* (issued on July 14, 2006 by (MOFCOM, NDRC, MOST, MOF, GAC, SAT, SIPO, SAFE, Shang Fu Mao Fa), the IDAR approach of the Chinese state was first published. It comprised of four key components: 1) 'Introduce' Chinese companies to foreign technologies through means such as inbound investments, establishing foreign R&D centres and collection of market intelligence; 2) 'Digest' technology by disseminating acquired information; 3) 'Absorb' foreign technology for domestic market through national innovation centres and laboratories and; 4) 'Re-innovate' to create internationally competitive products and core technologies.

The systemic design of technology transfers under the *Next-Generation Artificial Intelligence Development Plan* builds on this preceding policy framework.

Utilizing two key policy mechanisms, namely the *Measures on Administering Overseas Investment (MOFCOM, Shang Wu Bu Ling [2014] Order No. 3, issued Sept. 6, 2014)* and *Measures on the Administration of Examination and Approval and Filing for Records of Overseas Investment Projects (NDRC, 2014 Order No. 9, issued Apr. 8, 2014)*, strategic investments originating from the Chinese mainland have been directed towards strategic sectors complementary to development of an AI ecosystems such as Integrated Circuits where the capacity of Chinese state lacks considerably vis a vis that of the United States.

As shown in Graph 2.5, the number of investments in Chinese AI firms in US has grown exponentially, with the total number of deals crossing 80 and the total scale of investments by deal value crossing $1.3 billion.

Graph 2.5: Total Chinese investments in US Artificial Intelligence Companies between 2010 and 2017



Source: CB Insights

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The German Chinese Association of Artificial Intelligence[13] was established to "promote the exchange of educational resources between Germany and China in the field of artificial intelligence" by 1) promoting academic and professional exchanges; 2) organizing conferences, seminars and exchange activities for AI and; 3) supporting through an information and discussion platform, arranging internships, providing assistances in providing jobs and so on.

Acquisition of foreign technologies by Chinese MNEs is actively supported by state backed credit providers. For example the purchase of $4.2 billion worth shares of Kuka AG, a leading German manufacturer of industrial robots for factory automation by Midea Group Co., Ltd was supported by China Exim Bank through a loan of $870 million. In its Annual Report for the year 2016, Midea explained, "taking KUKA as a platform, we will continue the layout of industrial robots, commercial robots, service robots and artificial intelligence, and actively develop key components in the field of industrial automation."

Section 2.6: Artificial Intelligence + X - The development of allied industries

The uncertainties attached to the innovation process (Rosenberg, 1996) dictate that innovation takes place in clusters of innovation alongside complementary technologies and that the ex-ante uncertainty surrounding such technologies makes it harder to predict with certainty the success of the industry in question.

The ability for China to achieve the targets outlined in its AI Development Plan depends actively on the success of complementary technologies like high speed low latency 5G networks, high speed integrated circuits for processing complex machine learning algorithms and cloud computing Big Data solutions to operate on large datasets. This section describes China's stand on each of these key technologies in brief.

1) Semiconductors and Integrated Circuits

To fully utilise the advancements in new algorithms and software techniques, it is essential to develop hardware optimized for AI algorithms that allows higher levels of performance by combining multiple processing functions into a single step instead of the classic GPUs that undertake multiple steps to achieve the same results. Neuromorphic processors that replicate the functioning of the brain support running AI based applications and specialised chips need to be designed with tailored algorithms for use cases such as autonomous driving cars that require quicker response times and greater memory. Thus the importance of a strong semiconductor and IC industry for the development of an AI ecosystem cannot be emphasized enough. However, China (which is currently

[13] https://www.gcaai.org/statute/

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the world's biggest chip market, importing chips valued at over $200 billion annually) manufactures only 16 percent of the semiconductors it uses domestically. As has been witnessed in the crackdown of the US Federal Government on Chinese chip manufacturer ZTE in 2018, advancements in the domestic semiconductor industry is extremely critical for China and it makes for one of the priority industries under *Made in China 2025*.

In 2014 the central government set up the National Integrated Circuit Industry Fund. The fund, which has a registered capital of 98.7 billion RMB operates as a corporate entity under the MIIT and the Ministry of Finance while China Development Bank Capital (22.9% stake), China Tobacco, E-Town Capital, China Mobile, Guosheng Group, China Electronics Technology Group Corp, Beijing Unis Communications Technology Group and Sino IC Capital are among the pioneer batch of investors in the fund[14]. As we have seen in the example of Tsinghua Holdings and Tsinghua Unigroup in Section 1, this fund works in conjunction with multiple stakeholders involved in the ecosystem and allows for both domestic innovation as well as access to foreign technologies. As per one estimate, the total bids in US semiconductor industry emanating from China were valued at $34 billion (although only $4.4 billion in deals was completed). The fund and/or its key investors had a major role to play in that.

Some of the key developments in the Chinese semiconductor industry have come from both the private sector as well from government supported institutions. China's first AI Chip Unicorn, Cambricon raised funding worth $100 million in 2017[15] and has received a major motivational push after the launch of its cloud based smart chip, MLU100 that is a newer version of its erstwhile AI Processor Cambricon 1M (Cambricon licensed the designs from Silicon Valley chip designer Arteris for the key connections that move data around a chip). Others such as Spreadtrum are making strides in developing mobile chip platforms for supporting AI based apps as it announced its first Octa-core LTE SoC chip Spreadtrum SC9863.

On a larger scale, the development of high performance computing systems such as the Tianhe-2 (which uses Intel chips) and Sunway TaihuLight (which use Chinese manufactured Chips) supercomputers has provided China with cloud computing capabilities to integrate and compute inputs from large databases.

Here it is important to note that such AI based hardware machinery consumes a large amount of energy – but that is not a big impediment for China.

[14] http://www.scmp.com/tech/enterprises/article/2145422/how-chinas-big-fund-helping-country-catch-global-semiconductor-race
[15] https://www.yicaiglobal.com/news/china%E2%80%99s-first-ai-chip-unicorn-cambricon-bags-usd100-million-round-financing

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2) Big Data

The development of AI products in China has often been associated with the design of cloud computing platforms to support big data collection and processing (Center for Intelligence Research and Analysis, 2016). Big data facilities are required to extract, store and process data on which machine learning algorithms can be trained. The “Internet+” AI Three Year Implementation Plan (互联网+”人工智能三年行动实施方案) which was launched in May 2016, laid emphasis on rapidly setting up big data integration with cloud computing networks.

The provincial government of Guizhou has been laying key emphasis on building Guizhou’s Big Data ecosystem. According to the statistics released at the 32nd session of the 12th Guizhou Provincial People's Congress, in 2013, there were only less than 1,000 big data companies running in the province. After the promotion for the development and application of big data technology, big data industry skyrocketed to over 8,900 companies in 2017. A total of 28 big data scientific research institutions have also been set up in the province, as well as 23 incubators and investment organizations. The primary driver responsible for industry and much of the economic benefits accruing from the same is Guizhou-Cloud Big Data Industry Development Co., Ltd. (GCBD) which was approved by People's Government of Guizhou Province in November, 2014 and which kick started with a registered capital of 235 million yuan. The company has been tasked to promote the development of Big Data ecosystem in the province and is sponsored by Guizhou Big Data Development Administration and supervised by the Board of Supervisors of Guizhou State-Owned Enterprises. It is also dedicated to build an investment and financing platform for Guizhou Big Data and electronic information industry. It also owns large data processing, storage and mining capabilities that it offers to other firms

Such a concerted industrial ecosystem in the big data industry is likely to play to the advantage of Chinese firms such as Alibaba and Baidu that have set up their servers in ‘China’s Big Data Valley’ of Guizhou.

3) 5G Networks

In the June of 1956, with the US economy turning a new chapter post the Second World War, the Eisenhower administration decided to pass the Federal Aid Highway Act. The law authorized the construction of a network of interstate highways and roads that spanned a total length of approximately 41,000 miles across the nation. The goal was to improve coast to coast transportation and make it easy to evacuate cities in case of an atomic attack. What followed during the 1950s and 1960s was the rise of the American automobile industry. This in turn helped other industries in the command area of the automobile sector and a few related industries such as insurance, oil and gas, tooling and services to flourish.

In the advanced information based economies that the world is hyped to enter into, physical devices, home appliances and other electronics operating using network connectivity would depend on ultra-reliable and low latency communication. If the AI industry is considered analogous to the American automobile industry, 5G technology is the Interstate Highway System that would be needed for the rise of the internet based and advanced electronics industries that run on AI algorithms. Essentially, 5G would provide the scalability and reliability required to profitably implement business use cases such as autonomous vehicles and large scale robotic manufacturing that are presently only deemed as use cases for the future

China has attached great importance to 5G in its 13th Five-Year Plan (2016-20), with the aim of commercializing it by 2020. The China Academy of Information and Communications Technology, which is under the Ministry of Industry and Information Technology, published a report on 5G earlier this year. It forecasted that the 5G market will account for $167 billion (RMB1.1 trillion) — the equivalent of 3.2% of China's GDP and combined investment in 5G by the three domestic phone networks – China Mobile, China Unicom and China Telecom – would reach $47.5 billion (RMB313 billion) in 2023.

CHAPTER 3

What can India take away from this plan?

Concluding Remarks – A perspective from India

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Chapter 3: Concluding Remarks

China's Next Generation Artificial Intelligence Development Plan as a case study for India

Most growth in India's Artificial Intelligence ecosystem has so far been organic and led by private enterprises- many of which are either closely connected to the global ecosystem. According to a 2017 study[16], the value of the industry stands at an estimated USD 180 million in annual revenues. Additionally, more than 800 companies are reported to be working with AI in some form or the other in India, which however accounts for just 6% of global AI companies.

The Government of India has recognized the potential of Artificial Intelligence for the world's fastest growing economy[17]. The Budget presented by Finance Minister Arun Jaitley echoed this with USD 480 million allocated to the Digital India mission in the 2018 Union Budget, double of that in 2017. It also witnessed an increased allocation for NITI Aayog by more than 20%, defining a critical role for NITI Aayog in advancing AI and blockchain technologies[18]. In a follow up to the same, the NITI Aayog in its Discussion Paper titled, "The National Strategy for AI in India" in June, 2018 showcased India's desire to join the AI race and its challenges owing to its late entry, as compared to the US and China.

As India conceptualises its official Artificial Intelligence policy, the Next Generation Artificial Intelligence Development Plan can act as a good case study for catching-up economies.

Keeping an eye on standards and developments from China

The China Electronics Standardization Institute (CESI) under the Ministry of Industry and Information Technology (which also released a white paper on standardisation[19]) is an active member of the ISO/IEC JTC 1/SC 42 subcommittee, which is responsible for setting standards globally and whose first meeting was held in Beijing recently. CESI has been pushing for domestic standards developed in China such as "Specification of Programming Interfaces for Chinese Speech Recognition Internet Services" at SC42 and broadly China has been playing a

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[16] State of Artificial Intelligence in India; Gupta B., 2017 https://analyticsindiamag.com/study-state-of-artificial-intelligence-in-india-2017/

[17] https://www.economist.com/graphic-detail/2018/01/05/the-fastest-growing-and-shrinking-economies-in-2018

[18] http://pib.nic.in/newsite/PrintRelease.aspx?relid=176698

[19] http://www.cesi.ac.cn/images/editor/20180124/20180124135528742.pdf

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very active role in the global subcommittee. India should engage more actively with key players in China such as the Artificial Intelligence Industry Alliance, which is an industrial body comprising of around 200 members from different fields related to A.I. along with similar players placed globally.

Building closer collaborations

The Xiamen declaration of the BRICS 2017, recognizing the importance of innovation as a key driver for growth, released its first selection of projects adopted under the BRICS STI (Science Technology and Innovation) framework and emphasized on further supporting the implementation of the BRICS Innovation Cooperation Action Plan 2017-2020. Additionally, the declaration noted "We will engage in joint BRICS research development and innovation in ICT including the Internet of Things, Cloud computing, Big Data Analytics, Nanotechnology, Artificial Intelligence and 5G and their innovative applications to evaluate the level of ICT infrastructure and connectivity within our countries."

So far, multiple MoUs, letters of intent and agreements have been signed between stakeholders from India and China, however there has been little movement on that front and scientific collaboration between the two countries is almost non-existent. This must be changed, beginning by first bringing universities together to fund co-development of research projects. The Indian IT industry enjoys a good repute in China and Chinese researchers would be interested in participating with Indian stakeholders, especially because they are aware that western players are doing the same.

Concluding Statement

If data and information is considered as the currency for development of Artificial Intelligence then the Indian and Chinese economies are rich by measure of the vast availability of data. It provides the two economies with the big Big Data foundation to develop complex A.I. algorithms. Looking into the future, the Indian and Chinese economies are slated to be among the largest economies in the world. It is therefore imperative that their economies are not disconnected with each other, especially in the case of technologies that are set to define our future.