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China's Quest for AI Leadership: Prospects and Challenges

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Executive Summary

In 2017, the Chinese government unveiled a plan to develop the country into the world's primary innovation centre for artificial intelligence (AI) by 2030. In doing so, it identified AI as a strategic industry, crucial for enhancing economic development, national security and governance.

This report evaluates the strategy that has been adopted by the Chinese government in order to achieve these objectives. It examines the peculiarities of the Party-state-led economic model along with the evolving geopolitical and economic faultlines regarding trade and technology. In addition, it assesses China's policies with regard to factors such as core technologies, research, manpower, data and the commercial environment, which are crucial to ensure the development of the AI industry.

The assessment finds that the Chinese government's command innovation approach towards AI development is crafting a political economy that tolerates sub-optimal and even wasteful outcomes in the quest for expanding the scale of the industry. Consequently, going forward, the industry is likely to be plagued by concerns of overinvestment, overcapacity, quality of products and global competitiveness. In addition, increasing friction over trade with other states and President Xi Jinping's turn towards techno-nationalism along with tightening political control could further undermine China's AI industry.

Introduction

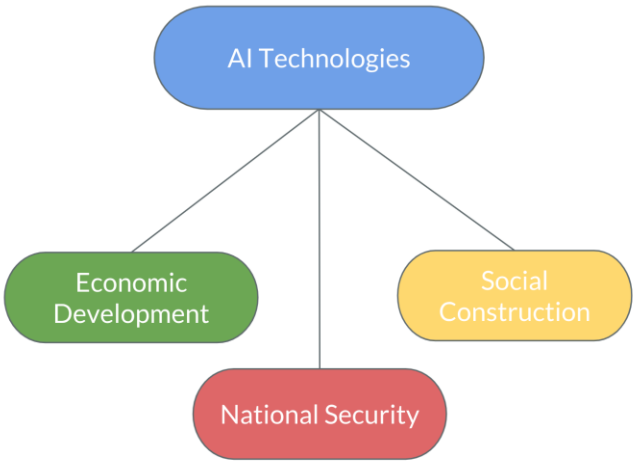
October 2017, the 19th Party Congress, President Xi Jinping outlined the objective of developing China into a "country of innovators," which is aiming for "the frontiers of science and technology."[1] The development of Artificial Intelligence (AI) technologies, which found a mention in Xi's speech, is critical for achieving that objective. A few months earlier, in July 2017, the State Council, the Chinese equivalent of the Cabinet of Ministers, had issued a landmark plan on the development of AI technologies in the country.

The document, *A Next Generation Artificial Intelligence Development Plan*[2], built upon previous technological and industrial development plans to provide an overarching vision for the development of AI in China. It categorically states the goal of developing China into a world leader in AI innovation by 2030.

The plan describes AI as the "new engine of economic development" and "a core driving force for a new round of industrial transformation."[3] In doing so, however, it does not view AI as a particular technology or a specific industry. Instead, it identifies AI as the next frontier of technological evolution, i.e., a set of technologies that enable the shift from 'digitization', 'networkization' to 'intelligentization', with the potential to positively impact a range of sectors. Given this context, this report, too, approaches AI from a broad perspective, defining it as a set of technologies that automate activities associated with human thinking, such as learning, decision-making and problem solving.

The above approach lends itself to the State Council distinguishing between certain sectors as core AI and others as AI-related. Core AI essentially covers specific, industry-agnostic technologies, while AI-related sectors cover applications that rely on core technologies and are relevant to specific industries.[4] Cumulatively, these can be considered as comprising the broad AI industry. The utility of such discrimination permits prioritisation, channeling of resources and phased development - all of which are important from the point of view of central planning.

The need for central planning and government support, i.e., systemic development, are underscored by the fact that the Chinese government views AI technologies as strategic in nature. The State Council's plan is categorical that AI technologies "will lead in the future" and their development is significant in order to "enhance national competitiveness and protect national security."[5]



Utility of AI as per State Council's plan

The plan, therefore, identifies the utility of AI technologies from three broad perspectives - economic development, preservation of national security and enhancing social construction.

From the point of view of the economy, the government anticipates AI to "inject new kinetic energy" in China's economic development, enabling manufacturing to move up the value chain and facilitating leaps in factor productivity. This is largely in line with the prevailing wisdom[6], with studies indicating a sizable GDP boost for China owing to advancements in AI.[7]

In terms of national security, the State Council's plan takes a macro view. The focus is on AI's role in supporting command systems and decision-making along with enhancing defense equipment and cybersecurity by boosting civil-military integration.[8] It is important to point out at this stage that deepening civil-military integration is not an AI-specific policy. Civil-military integration was upgraded to national strategy status in March 2014. Following that, in January 2017, the Politburo of the Communist Party of China announced the establishment of a new Central Commission for Integrated Military and Civilian Development headed by Xi.[9] Civil-military integration, therefore, is a larger national agenda, with AI technology development in the civilian sector likely to serve military purposes.[10]

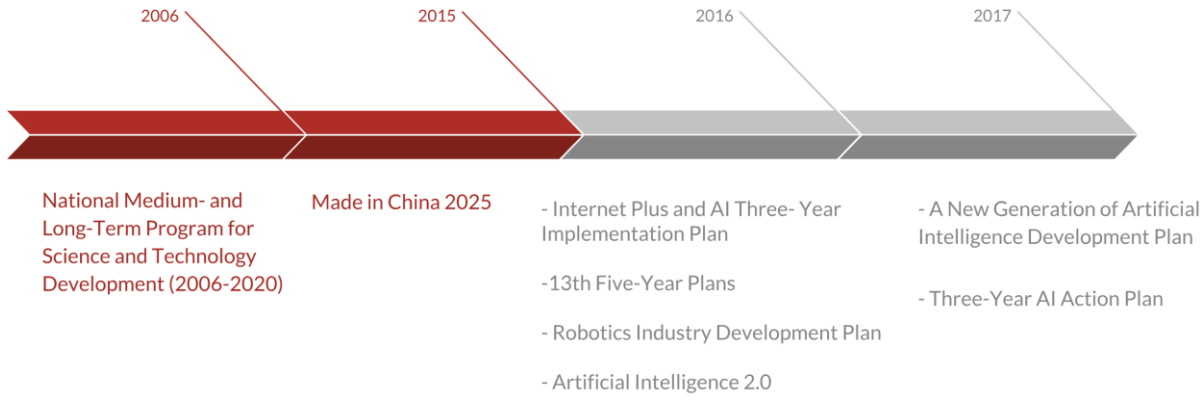
Finally, the rather awkwardly phrased concept of social construction encompases the notion of building an "intelligent society." In this viewpoint, AI advancement can help enhance the overall governance capacity of the state in terms of more effective provision of public goods. In addition, such technologies can improve efficiency across sectors such as education, healthcare, judicial services, policing, transportation, etc, leading to overall improvement in people's quality of life.[11]

The rest of this report examines and evaluates the strategy adopted by the Chinese government in order to achieve these objectives. The second section locates China's AI strategy within its broader approach toward industrial development, examines the political economy of AI development in China and

offers a comparative assessment vis-a-vis AI plans of major international competitors. In the third section, this report explores the four ingredients fundamental to China's AI strategy and assesses the Chinese leadership's approaches with regard to each of these. The concluding section distills the analysis to identify three broad factors that are likely to impact the development of AI in China, hindering its quest for global leadership.

Devising the Strategy

The State Council's July 2017 AI plan was primarily a product of the gradual recognition by China's policy-making elite of the significance of AI technologies for the country's industrial and economic development. The plan was also an attempt for government policy to catch-up with and leverage the rapid technological advancements being pioneered by Chinese and global enterprises, which were impacting the country's socio-economic landscape.



AI's rise in Chinese government's development agenda

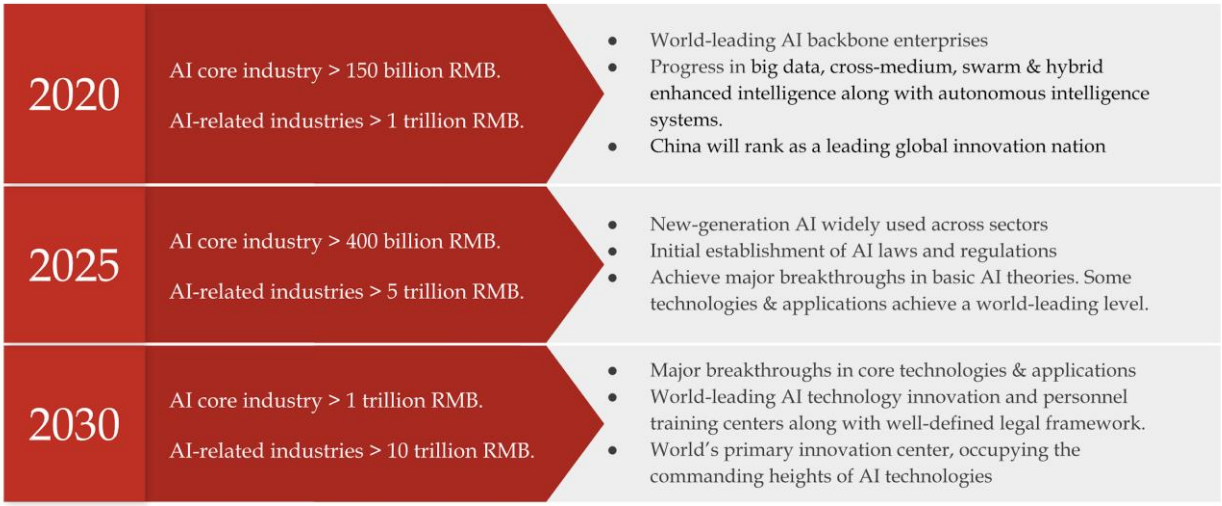
Early signs of government focus on intelligent and frontier technologies are evident in the *National Medium- and Long-Term Program for Science and Technology Development* (2006-2020). In 2012, the State Council identified the need to support "intelligent equipment-manufacturing industry" as a "strategic emerging industry."[12] This view was further strengthened with the formulation of the Made in China 2025 plan, which provides a decade-long blueprint to transform China "from a manufacturing giant into a world manufacturing power" through intelligent and innovative technologies.[13]

In the subsequent year, development of AI technologies was repeatedly highlighted as a priority in a range of key central government plans. In many ways, as earlier plans suggest, this was an organic progression that had been underway. However, Google DeepMind's AlphaGo's victory against South Korean Go grandmaster Lee Sedol in March 2016 undoubtedly galvanised public debates[14] and strategic thought[15] towards the significance of AI for China's security and

economic development. This resonated in priorities articulated in subsequent government plans.

The *13th Five-Year Plan* (2016-2020) issued by the State Council stressed on the need to focus on AI and robotics, with the aim of facilitating the "commercial application of artificial intelligence technologies." This was further supported through the *Robotics Industry Development Plan* (2016-2020), which aims to boost annual production of industrial robots to 100,000 by 2020.[16] Thereafter, in May, the *Internet Plus Artificial Intelligence Three-Year Action Implementation Plan*, jointly issued by key national-level government bodies, identified the need to set up basic AI innovation infrastructure and expand the scale of AI industry to "hundreds of billions" of RMB.[17] In August, the *13th Five-Year National Science and Technology Innovation Plan* launched 15 "Science and Technology Innovation 2030 Megaprojects," with *AI 2.0*, a plan proposed by the Chinese Academy of Engineering being added as the 16th Megaproject in February 2017.[18] Thereafter, in March 2017, the term AI found its first ever mention in the Premier Li Keqiang's Government Work Report to the National People's Congress, the country's top legislature.[19]

With this background, the July 2017 plan harmonised multiple strands of thought and policy initiatives towards AI development to produce a single vision document. The document identifies three phases of development for China's AI's industry till 2030, with specific quantitative and qualitative targets. In terms of scale of industry, the plan aims that by 2020 core AI industry must exceed RMB 150 billion, with scale of related industries exceeding RMB 1 trillion. These figures are projected to touch RMB 1 trillion and RMB 10 trillion, respectively, by 2030.



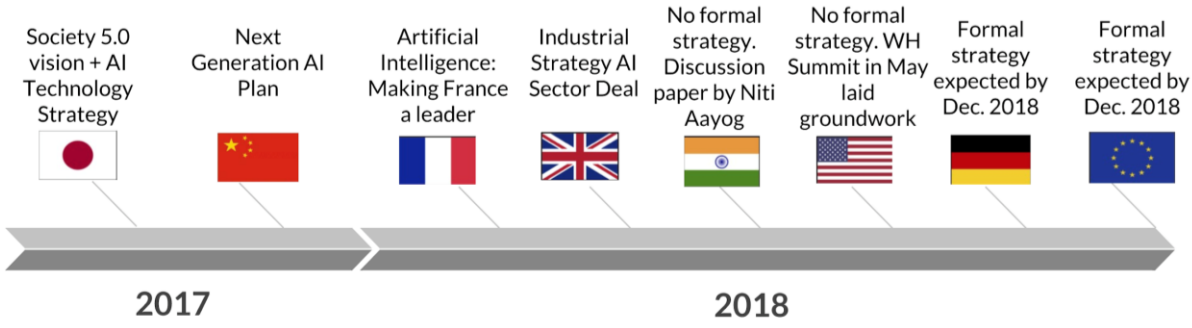
Targets outlined in State Council's AI plan

Independent assessments and even those published by Chinese think tanks and state media indicate that these targets are nothing short of extraordinary considering the current scale of China's AI industry. For instance, the Ministry of Industry and Information Technology estimates that China's AI industry output in 2017 was RMB 18 billion ($2.63 billion).[20] China Daily's June 2, 2018, report quotes Ernst & Young data estimating the scale of China's AI industry in 2017 at RMB 15 billion ($2.19 billion).[21] Wuzhen Institute, a Chinese think tank, estimates the scale of China's AI industry as touching RMB 34 billion ($4.96 billion) in 2017.[22] Tsinghua University's *China's AI Development Report* 2018, meanwhile, estimates the market value of China's AI industry at RMB 23.7 billion ($3.46 billion).[23] In February 2018, Xinhua cited iiMedia Research Group data as estimating the scale of China's AI industry in 2019 at RMB 34.43 billion ($5.44 billion).[24] While these estimates vary significantly, what they do indicate is that achieving the 2020 target outlined by the State Council is a rather tall order. This is particularly the case with some assessments now suggesting that growth in China's AI sector will decelerate after peaking in 2018.[25]

Apart from such quantitative targets, the State Council plan also indicates what analysts like Elsa Kania term "an integrated, whole-of-nation approach" to AI development.[26] The plan is, in effect, a guiding document or a call to action for local governments, businesses, academica, individuals and organisations working across sectors to "firmly seize the major historic opportunity for the development of AI."[27] At the heart of the strategy are four key factors - i.e., technology and talent, research and rules, data management and a commercial ecosystem - which would be the key determinants of success for any state in its quest for AI leadership.[28]

An assessment of the AI policies/strategies of other states also indicates an appreciation for these factors. For instance, while the United States does not have a national AI strategy, the White House's summit on AI in May 2018 identified supporting national R&D ecosystem, providing open access to taxpayer funded data, boosting investments in STEM and computer science education, enabling the creation of new industries along with playing a role in global standard setting as key action points.[29]

On the other hand, the UK's *Industrial Strategy AI Sector Deal*, calls for establishing Data Trusts, sets specific targets for government-supported researchers and R&D investment and calls for establishing an AI Council for industry, academia and government to work together.[30] The European Union, meanwhile, is expected to publish its AI strategy later this year. However, in April 2018, the European Commission published a document titled *Artificial Intelligence for Europe*, which seeks the development of an EU-wide strategy keeping in mind the four above-mentioned factors.[31] In the interim, key EU states like France[32] and Italy[33] have already begun framing their policy positions, while Germany is expected to publish a formal strategy by December 2018.[34]



Emerging global AI competition

The approaches of different states are by-and-large determined by a range of political, economic and social factors. These include national and business interests, availability of and ability to direct capital, technological and research base, political will and systems, demographics along with attitudes towards data, privacy and new technologies. Beyond the narrow specifics, what distinguishes China's strategy from those of some of the other major international actors is the peculiarity of the Chinese system of governance. It is the Party-state structure that is shaping the bureaucratic and business incentives, which in turn are crafting a political economy around the development of AI in the country.[35]

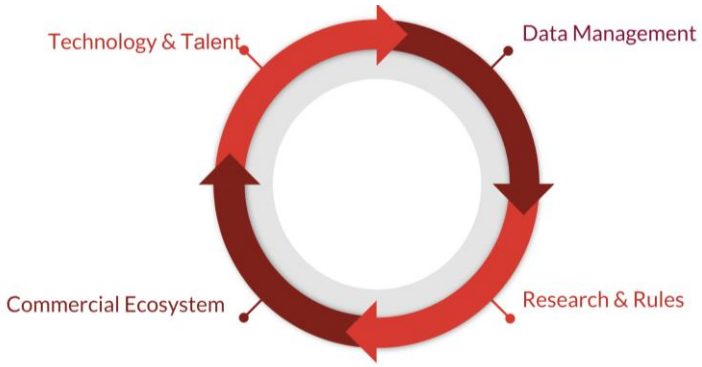
The central government's gradual emphasis on AI over the years and its subsequent elevation through the release of the State Council's development plan provide potent signals to subnational governments. In China's hierarchical and

unitary governance system, such signalling not only lends direction to state and private capital but also frames political priorities of local leaders desiring to rise up ranks. While consolidating power as China's *core* leader, Xi Jinping has identified "political integrity" as the "foremost criterion for selecting officials" and stressed that "the fundamental task" for local Party organisations is to ensure the implementation of Central Committee decisions.[36] In addition, Xi has increasingly emphasised the need for China to become self-reliant in core technologies, achieve breakthroughs and integrate new technologies such as AI with the real economy.[37] Self-sufficiency in the tech sector, therefore, is rapidly being prioritised over efficiency. Directives such as these, along with quantitative targets set by the central government, help frame the financial and political incentive architecture for local leaders.

The result is evident from the ambitious plans issued by a number of local governments across the country. Taking cue from the State Council, as of May 2018, at least 18 provinces, regions and municipalities have announced specific AI plans.[38] A report published by the Qianzhan Chanye Research Institute in March this year evaluated 12 of these plans to find that the sum of their targets for scale of core AI industry by 2020 was approximately RMB 429 billion ($62.5 billion), which is nearly three times the national target set by the central government.[39] This is indicative of the budding competition among local governments for Beijing's approval and largesse along with private capital, which deepens local protectionism and distorts the market. Considering this, a report by the Mercator Institute for China Studies argues that while such "enthusiasm of local governments will accelerate China's AI development considerably, it also carries the risk of creating overcapacities."[40]

Beyond the scale of industry targets, there are certain other features of these local plans that are noteworthy. First, a number of them call for the establishment of dedicated AI industry parks or hubs. For instance, Shanghai aims to build AI industrial clusters across the city with different focuses such as intelligent driving, intelligent robots and intelligent software and hardware,[41] while Beijing is planning to build an RMB 13.8 billion ($2.01 billion) AI intelligence development park.[42] Second, most local governments are looking to leverage their distinctive advantages while devising their AI strategies. So Anhui province is seeking to build on the speech recognition expertise available in the capital city, Hefei.[43] Hebei province wants to focus on intelligent equipment and manufacturing industries.[44] And the Hubei provincial government is banking on leveraging the clout of the East Lake High-tech Development Zone (Optics Valley) in Wuhan to develop an AI industrial cluster of global influence.[45]

The Four-Pronged Approach



Factors key to AI industry development

Four factors lie at the heart of China's vision for global AI leadership - technology and talent, research and rules, data management, and a commercial ecosystem. Each of these are not only fundamental to AI development but they are also interlinked and significantly interdependent, with advancements in one area contingent upon and supportive of advancements in others. This section outlines and assesses the policies and approaches that have been devised and implemented with regard to each of them.

Technology and Talent

Advanced hardware capacities, such as high-end CPUs, GPUs, TPUs and FPGAs, are critical for AI development and innovation.[46] Despite being the world's biggest semiconductor market, data shows that China manufactures only around 16% of the semiconductors it uses domestically.[47] Estimates suggest that as of 2015, China accounted for only 4% of the global semiconductor production market share.[48] The country reportedly imported $227 billion worth of integrated circuits in 2016, an amount greater than its combined imports of crude oil, iron ore and primary plastics.[49] This is the scenario despite massive capacity upgrades in the past decade.[50] Therefore, starting with the Made in China 2025 policy, the Chinese government has set out clear self-sufficiency targets - 40% by 2020 and 70% by 2025 - with regard to integrated circuits.[51] The roadmap to achieve this is through increased government spending aided by the China Integrated Circuit Industry Investment Fund,[52] establishing focused industry clusters, allowing local private-equity firms to allocate public funds, supporting consolidation in the domestic market and encouraging overseas partnerships, mergers and acquisitions.[53]

Given China's dependence on imports, M&As and global partnerships, the success of this strategy is heavily contingent on geopolitical factors. In this context, growing frictions with the US and Europe over trade and market access, intellectual property rights and allegations of forced technology transfers pose a clear and present threat. In response, the Chinese government appears to be

tilting towards a nationalistic narrative of self-reliance.[54] In May 2018, Xi Jinping outlined a new approach to develop China into a science and technology leader, calling for core technologies to be "self-developed and controllable" with the initiatives of innovation and development being "securely kept in our own hands."[55] While such an approach is likely to expand state support, it could potentially adversely impact the pace and quality of core technology industry development in China, along with deepening frictions with international actors.

In addition, adopting a techno-nationalist approach could hinder academic, business and research partnerships. The most immediate impact of this is likely to be the reduced attraction of China as a destination for international AI talents. Estimates of the global AI talent pool vary widely. However, the common consensus is that there is an acute shortage of talented people. According to the People's Daily, China faces a severe AI talent shortage with over 5 million professionals urgently needed.[56] The Tencent Research Institute's 2017 Global AI Talent White Paper estimates that there are around 300,000 AI researchers and practitioners around the world, with 200,000 of them already employed in various industries.[57] Recognising the development of high-quality talent as a matter of "utmost importance," the State Council's plan calls for a training and gathering approach.[58] This involves attracting the best talents globally, along with training Chinese citizens while building a new AI academic discipline.[59]

To attract worldwide talent in AI, there has been a concerted effort to offer extremely competitive salaries,[60] easier visa processes, financial[61] and non-financial incentives[62] and specific subsidies to enhance living standards.[63] Data on overall employment suggest that such policies have resulted in some gains in attracting talent, with China jumping 11 places to the 43rd position in the The Business School for the World (INSEAD) Global Talent Competitiveness Index from 2017 to 2018.[64] Moreover, improving career prospects, particularly in the technology sector, have meant that increasingly Chinese international students are returning home after their education overseas.[65]

Despite this, serious concerns remain about China's ability to attract sufficient high-quality talent. First, despite improvements, China continues to lag behind in the US and major European states in terms of talent competitiveness. And as their plans suggest, these states are also in the race for top talents. Second, the socio-political and cultural peculiarities of China, with increased censorship and a more strictly walled Internet, can potentially hamper its attraction. Western states would likely face a similar problem if populist, anti-immigrant and xenophobic movements were to continue to grow in scope and intensity.

In terms of the training component of this strategy, over the past few years an increasing number of Chinese universities have been introducing AI courses.[66]

Following the State Council's 2017 guideline, in April 2018, the Ministry of Education released its first AI Innovation Action Plan for Colleges and Universities. The plan aims to establish China's universities as hotbeds for AI talent by 2030.[67] The first step towards this is to bring out 50 world class AI textbooks; set up 50 national-level high quality online AI courses and establish 50 AI research centres by 2020. Along with this, the Ministry of Education also wants to train 5,000 students and 500 teachers in AI within five years.[68] In June 2018, SenseTime and the East China Normal University published the first Chinese high-school AI textbook.[69] In addition, an increasing number of academic institutes are partnering with domestic and foreign enterprises to set up research and training labs.[70] While China has begun to increasingly attract a larger share of the international student pie,[71] analysis of data from Elsevier's Scopus database shows that when it comes to AI education Chinese institutions lag behind their Western counterparts.[72]

Research and Rules

Assessment of research capacities involve quantitative and qualitative measures. From a purely quantitative viewpoint, Elsevier data from 2011 to 2015 show that China has long surpassed the US, its closest competitor, in terms of the number of papers published on AI.[73] In its 2018 *China Artificial Intelligence Development Report*, Tsinghua University estimates that China's share of AI research papers published globally has grown from 4.26% in 1997 to 27.68%.[74] The report also claims that China holds the most AI patents, inching ahead of the US and Japan. However, given that China is in a catch-up phase vis-a-vis international competitors in terms of its technological base, the cost it incurs to generating a patent is significantly higher than countries like Japan and Germany.[75] Moreover, data regarding numbers of patents simply associated with the term AI are an insufficient gauge of quality.[76] Data on research citations and their weighted impact offer a far more comprehensive qualitative perspective.

In this regard, Elsevier data from 2011 to 2015 placed China at the 34th position in terms of field-weighted citation impact. The US, in contrast, was ranked 3rd. However, that trend appears to be changing. SCImago Journal & Country Rank, which is based on citation data derived from the Scopus Database, evaluates China's 2017 H-Index value in the AI subject area at 213, i.e., the third highest after the US's 479 and the UK's 228. In addition, there has been a sharp spike in Chinese authors' clout at international AI conferences, indicating qualitative improvements. For instance, an assessment of the papers presented at the annual conference of the Association for the Advancement of Artificial Intelligence revealed that 23% of the authors who presented papers in 2017 were Chinese,

compared to just 10% in 2012. The share of US authors, meanwhile, fell from 41% to 34% during the same period.[77]

As impressive as the above-mentioned trend appears, certain structural impediments are likely to persist. Over the years, a flawed incentives structure, such as high stress on meeting numerical targets and making breakthrough achievements, has led to the emergence of a perverse black economy of research in China.[78] The Chinese Party-state's attempts to intensify political control are only likely to lead to the persistence of this trend. For instance, online information flow in China is already restricted. In this environment, the State Council's new regulation on scientific data management aims to further deepen political control over research and international collaboration.[79] The regulation calls for scientific data centers to be "supervised by authorities." It demands that data produced by government-funded research that are used to write papers and for publication in foreign academic journals be first submitted for review. Additionally, privately funded research must also be first reported if it impacts state secrets, national security and the public interest. The challenge for Beijing, therefore, is to foster a regulatory environment that enables collaborative, authoritative and ethically responsible research while meeting political objectives of control and stability. How the Chinese government strikes this balance will also be one of the key determinants of its ability to influence the debate around global norms, ethics and standards governing AI, which is fast emerging as a priority area.

The State Council's plan acknowledges the potentially disruptive nature of AI technologies, and calls for attaching great importance to minimising risks and ensuring safe, reliable and controllable development of AI.[80] It, therefore, calls for establishing initial AI technology standards by 2020 and a focus on certain ethical concerns, such as privacy and displacement of jobs, while framing AI regulations. Following from that, in January 2018, the Standards Administration of China issued a White Paper on Artificial Intelligence Standardization. The document focuses on the significance of standardisation in promoting technological innovation and supporting industrial development, which in turn would make Chinese enterprises and products more competitive internationally. It also offers a Chinese perspective on evolving ethical and regulatory issues, such as liability, intellectual property rights, data security and privacy.[81] Thereafter, in April 2018, Beijing also hosted the first meeting of an international committee set up to deliberate international standards on AI.[82] In addition, different local governments have already begun framing regulations for testing technologies like self-driving cars.[83] The impact of such early steps in China's march for leadership in AI standards, however, is likely to be limited if the nationalistic narrative and security concerns grow more prominent.

Data Management

Data is the primary fuel for AI development, with China often seen as enjoying an edge in this context. This is largely due to four factors. First, over 57% of the Chinese population, which is roughly over 800 million people, now have access to the Internet.[84] The comparative numbers for the United States and India are estimated at 326 million and 481 million, respectively.[85]

Second, the lack of effective privacy protections ensure that there are fewer constraints with regard to accessing data. China's legal frameworks privilege the state's rights over individuals and enterprises. As Lotus Ruan has argued, there is no uniform law or a national authority to ensure or coordinate data protection in China, despite 15 years of discussions on such policies, and neither is there an independent privacy watchdog.[86] Third, the Chinese public appears to have a far more relaxed view with regard to privacy protections, particularly in the context of the state having greater access to private data. This is evident in the popularity of the rapidly developing Social Credit System.[87] All of this has lent credence to the view that Chinese citizens and consumers are more willing to accept the trade-off between privacy and better goods, services and security.[88]

However, it is important to keep in mind that this does not imply that privacy is not a matter of concern for Chinese consumers. Data from the Internet Society of China also show that 54% of Chinese Internet users hold the view that privacy breaches are a severe problem, particularly given the rising cases of fraud and theft.[89] In addition, social media outrage against Baidu's Robin Li for arguing that Chinese people tend to disregard privacy for convenience[90] and official criticism of Ant Financial for violating personal information security standards also indicate shifting attitudes.[91] One can locate the Chinese government's increasing efforts at framing data protection and usage laws within this changing environment.[92]

Therefore, new Chinese laws are increasingly aiming to protect against misuse of data by companies, without placing such restrictions on the state. This leads us to the fourth factor, i.e., as a consequence of the above, increasingly Chinese private companies, which have a wealth of diverse data sets, are building their business models around the needs of the state.[93] This is crucial to note, given that AI development has been identified as a strategic priority by the state. As a result, the state wields strong influence over tech companies, which in turn enables resource sharing and coordinated action. This is reflected in government plans, which call for "launching open public data reform pilots to support the public and enterprises in fully tapping the commercial value of public data"[94] and enhancing the "openness and sharing of common AI technologies, resources, and services."[95]

In comparison to the Chinese system, governments in democratic societies often tend to struggle with the conflicting imperatives of protecting individual privacy and promoting business interests and development of new technologies.

Despite such structural issues, it is important to note that the mere availability of large quantities of data does not imply a winning advantage in terms of AI development. The qualitative component of training data for AI systems is crucial, particularly if these systems are to serve as standard bearers internationally. Among other things, quality is primarily a factor of diversity, technology and manpower, and China's challenges in these contexts have been outlined above.

The 2015 racism controversy around Meitu, an app that uses AI technology to beautify selfies, was a product of such data limitations.[96] It is, therefore, unsurprising that an increasing number of Chinese high-tech firms, particularly those working in the field of computer vision and facial recognition are turning to international markets.[97] However, such efforts can potentially be threatened by growing concern about linkages between Chinese firms and the government.[98] In addition, laws that restrict cross-border transfer and mandate data localisation, such as the Chinese Cybersecurity Law which went into effect in June 2017, could limit data flow to China, impeding its AI development.[99] Therefore, the success and global competitiveness of China's AI development is likely to be contingent on the ability of the state and enterprises to mitigate such threats and expand development.

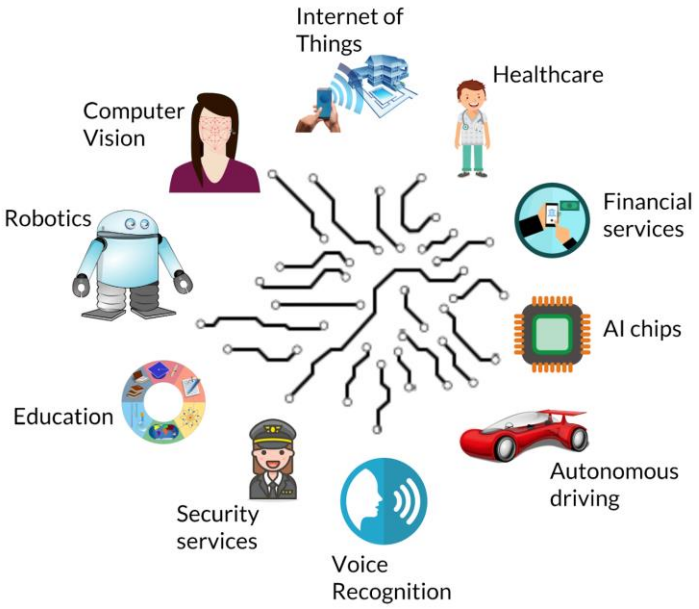
Commercial Ecosystem

The Chinese Party-state is intimately involved in the development of the country's AI sector. To foster growth and meet the targets that it has laid out, the Party-state broadly performs four distinct functions. It is a regulator, investor, partner, and consumer.

Therefore, in November 2017, the Chinese government announced a major partnership with private enterprises to boost AI development. The Ministry of Science and Technology identified tech giants Baidu, Alibaba Group, Tencent Holdings and FlyTek as national champions that would spur advancements in AI in the country.[100] Each enterprise was tasked with a specific focus area, with commitments of government support. This underscores the deep linkages between private enterprises and the state in terms of China's approach to technology development, and while such an approach might encourage focussed development in certain areas, it also results in market distortion. Assured state support for certain firms undercuts competition and can encourage moral hazards, resulting in greater prevalence of and tolerance for suboptimal

outcomes.[101] An excellent example of this is the recent iFlytek controversy, with the company being accused of hiring humans to fake its simultaneous interpretation tools, which said to be powered by AI.[102] Along with engendering problems as this, such a policy raises entry barriers for new innovators, undermining new ideas and enterprises.

Following this announcement, the December 2017 three-year AI action plan issued by the Ministry of Industry and Information Technology emphasised that technological developments must be driven by market demand.[103] In this context, the plan identified industry, healthcare, transportation, agriculture, finance, logistics, education, culture, and tourism as key sectors for development of smart products.[104] In addition, sectors such as household appliances, elderly care and retail have also come into focus, given that the impact of AI in these sectors figured among conversations during the annual NPC and CPPCC sessions this year, with industry leaders being invited to talk to delegates.[105]



Focus areas of China's top 50 AI companies (Data: China Money Network)

Such signalling by central authorities acts as an important guide for local governments, state-owned and private enterprises to direct their attention, with state support likely to be concentrated for activities in these sectors. This, in turn, also tends to attract the attention of central and local guidance funds, venture capitalists and foreign investors. [106] For instance, the China Money Network's China AI Top 50 rankings estimate that 27 of the top 50 AI firms in China are backed by Chinese government-related funds and/or Baidu, Alibaba and Tencent.[107] Moreover, signalling by Beijing also involves highlighting priority areas

where the state is likely to be one of the primary customers, owing to its broader objectives and the role of state-owned enterprises. For instance, reports increasingly suggest that the Chinese government is relying on the use of big data and facial recognition technologies to meet objectives of improved governance, traffic management, security and stability.[108] In addition, it is often a political imperative for SOEs to adopt new technologies, thereby acting as ready customers supporting innovation.

Already, this has had a significant impact in terms of the number of players and size of the AI industry in China. The Beijing Municipal Commission of Economy and Information Technology estimates that China is home to around 4040 AI firms, with 1,237 of them having acquired venture investment.[109] In contrast, a new report by the China Institute of Science and Technology Policy at Tsinghua University estimates that there are 1,011 AI companies in the mainland.[110] This massive discrepancy is in part a product of the fuzziness with regard to the definition of what constitutes an AI company. Despite this, the trend line when it comes to the number of companies working in China's AI industry is upward sloping.

A new report by Yiou Intelligence claims that between 2014 and 2017 around 700 AI-creating enterprises in China obtained investment surpassing 100 billion yuan (approx $14.5 billion).[111] China Money Network's rankings identify 14 unicorns among the country's top 50 AI companies.[112] Research by CB Insights shows that out of the $15.2 billion invested in AI startups globally in 2017, 48% went to China, with US firms accounting for just 38%.[113] This is the first time that Chinese AI startups have surpassed their US counterparts in terms of fundraising. Early gains have also been witnessed in areas like facial recognition, intelligent speech,[114] retail[115] and healthcare.[116]

However, while the numbers have swelled, there are serious questions about the quality of Chinese AI startups along with structural issues related to market distortion. SenseTime's Yang Fan and investors like Everbright's Ai Yu have argued that the fundamental challenge for Chinese AI startups is commercialisation of new technologies, which need to be focussed on real demand.[117] This, they argue, is likely to come into greater focus as the initial flow of funding begins to slow down. Such assessments indicate that already there are concerns about overcapacity, quality and inefficiency and the emergence of a bubble. Addressing this is likely to require greater and continued government intervention in the AI sector, which will further have implications for quality and capacity for innovation.

Developments in China's robotics industry potentially offer a window into the future of China's AI sector, given the similarities in approach towards their

development. In 2015, China identified robotics as a major industry as part of its Made in China 2025 plan. Thereafter, the government issued a separate five-year Development Plan for the Robotics Industry (2016-2020). The plan was devised amid recognition that China had already grown into the largest market for industrial robots in 2013, with targets emphasising self-sufficiency by increasing the market share of domestic suppliers. For instance, the country wants to be able to manufacture at least 100,000 industrial robots annually, expanding domestic production and reducing foreign dependence. Since the launch of the plan, the industry has witnessed rapid growth in scale. In 2017, state media reported that China had already hit the target of producing 100,000 industrial robots.[118] China was also reportedly home to some 6500 robotics companies, with total sales of industrial and service robots estimated at $5.5 billion.[119] Despite this, serious challenges remain with regard to overcapacity, quality of products and competitiveness.[120] For instance, according to the China Robot Industry Alliance, the market share of domestic suppliers, which had risen to 32.7% in 2016, slipped to 26.8% in 2017.[121] Senior government officials like Xin Guobin, Vice Minister of Industry and Information Technology, have also repeatedly acknowledged the structural concerns that plague the sector.[122] Given the similarities in China's approach to the development of the robotics and AI sectors, the potential of a similar story unfolding remains high.

Conclusion

Based on the above analysis, it is clear that the size of the Chinese market, the availability of large amounts of capital, an increasingly educated workforce with an entrepreneurial spirit, easy access to large quantities of data and a government that is keen to nurture and leverage these factors is a potent recipe to foster innovation. However, there exist key structural, geopolitical and geoeconomic constraints that can hinder China's quest for global leadership in AI, as desired by the State Council's plan.

First, the Chinese command innovation architecture emphasises scale over efficiency and quality. This process shapes the political and economic incentives of researchers, enterprises and local governments. While this often results in greater allocation of resources, support for enterprises and sectoral growth, it also leads to structural problems like wasteful investment, overcapacity, domestic protectionism and a tolerance for suboptimal outcomes. This, in turn, is likely to limit innovation and quality, and therefore, global competitiveness. An additional factor to bear in mind in this context is China's already heavy debt burden.[123] Availability of capital through increased debt has played an important role in the expansion of heavy industries and the technology sector[124] in China over the past decade.[125] However, China's current debt burden and the government's policy of

deleveraging to limit financial risks[126] hinder the replication of that financing model when it comes to new technologies.

Second, demand, market size and access controls have traditionally been key components of Chinese government's toolkit in attracting foreign players and guiding their actions. This has been evident even in the context of the development of AI.[127] However, geopolitical changes, such as deepening international competition as different states pursue their own AI strategies, the rise of protectionist sentiment, particularly in the US, and the increasing techno-nationalist approach of President Xi Jinping are likely to shape the environment within which China's AI sector develops in the near future. The State Council's plan recognises that China is currently in a catch-up phase with regard to core technologies. This is evident in the quantum of China's imports of chips and semiconductors and the impact of the Donald Trump administration's ban on Chinese telecommunications equipment maker ZTE. A further intensification and confluence of these two currents of competitive protectionism globally and techno-nationalism at home are likely to lead to increased limits on the transfer of technology from Western firms to China, greater restrictions on M&As in the technology sector, greater scrutiny of Chinese investments, reduced international collaboration between enterprises, institutions and researchers and a greater tendency for data localisation. Statements by senior Chineses leader during the recently concluded World AI Conference in Shanghai indicate an acknowledgement of the danger of such a situation.[128]

Finally, the Chinese government's plans related to AI suggest a sense of unease in terms of the potential unintended consequences of technological development. The State Council's 2017 plan, in fact, warns of the need to "minimize risk, and ensure the safe, reliable, and controllable development of AI." Essentially, this is an extension of the stability versus growth dilemma that successive Chinese leaders have faced over the decades. At present, the primary concern is the impact of the development of new technologies like AI on employment, which could impinge on social stability.[129] However, there are other concerns with regard to loosening political control. The most recent example of this dynamic is evident in the public apology issued by Zhang Yiming, founder and CEO of content aggregator Toutiao, which uses AI algorithms to deliver personalised content to users. Zhang's apology underscores the challenge that the Communist Party faces in pursuing AI development, i.e., ensuring that algorithms adhere to core socialist values.[130] Such an objective impinges negatively on innovation and reduces China's attractiveness for international talent, which in effect will have an adverse impact on China's quest for global AI leadership.

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