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Techno-industrial Policy for New Infrastructure: China's Approach to Promoting Artificial Intelligence as a General Purpose Technology

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Abstract

Scholars connect China's technology policy to government interventions that target particular industrial sectors. But not all sectors are created equal. Relying on evidence from China's Artificial Intelligence (AI) policies, this paper develops a framework for assessing China's approach toward promoting a technological domain that permeates across many industrial sectors: general-purpose technologies. It shows that China's AI strategy diverges from expectations derived from typical characterizations of China's industrial policy, which stress an emphasis on self-sufficiency, support for a limited number of national champions, and the essential role of military investment and demand for progress in dual-use domains.

Keywords: Emerging technology, geopolitics, economic security, artificial intelligence

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I. Introduction

In the past few years, no other nation's technology policy has drawn more scrutiny than China's. U.S. strategists view Chinese policies like Made in China 2025 as "the real existential threat to U.S. technological leadership."[1] European planners assess how China's technology initiatives could increase European dependence on Chinese products and supply chains.[2] At the same time, developing countries have long considered the Chinese model for science and technology as a possible path toward sustainable development.[3]

Recent scholarship on China's approach to fostering technological innovation has identified a major shift toward "techno-industrial policy."[4] Other scholars observe that techno-nationalism, or the employment of protectionist policies to secure high-tech industries, is experiencing a "resurgence" in China.[5] Taken together, these two trends define China's technology policy in terms of direct government interventions that target particular industrial sectors.

It seems only natural to understand China's AI policy in these terms. One analyst, for example, states that techno-nationalism in China "reached an apogee" with the release of a national action plan for AI.[6] Yet, not all sectors are created equal. In fact, one of the defining characteristics of AI is its general-purpose nature, which complicates attempts that analyze China's AI policy through a sectoral lens.

Adapting insights on general-purpose technologies (GPTs) from the economics and economic history literature, this paper develops a framework that illustrates how GPTs demand policy responses that differ from industrial policy aimed at securing critical segments of strategic sectors. Unlocking the value of GPTs entails extensive coordination between innovating firms in the GPT sector and numerous application sectors. In contrast, in other sectors targeted by industrial policy such as key semiconductor components or aircraft, this prioritization of open flows of information could be detrimental, because it would increase the risk of leaked technical secrets for innovating firms.

1 Laskai 2018.

2 Seaman et al. 2022.

3 Rifkin 1975

4 Chen and Naughton 2016.

5 Kennedy 2013, 911.

6 Joseph 2019, 200.

I posit that there are three main differences between the optimal policy responses to GPTs and how the recent literature assesses China's industrial policy.[7] First, general accounts of China's efforts to promote emerging technologies tend to emphasize efforts to reach self-sufficiency targets, whereas a GPT-oriented approach is more conducive to open information flows that often cross borders. Second, whereas China's technology strategy is often characterized in terms of direct government interventions that champion a few national firms, GPT-based policies place more value on the linkages between the GPT sector and countless application industries. Third, while analysts consider the People's Liberation Army's involvement as a necessary boost for the incubation of certain dual-use technologies, military demand and procurement is not necessary for spurring the development of GPTs. Since the civilian economy presents many more application scenarios than the military realm, momentum for a GPT's evolution lies in the former, not the latter.

In sum, GPTs impose demands that conflict with the conventional toolkit Chinese policymakers use to target technologies that can more easily be contained within sectoral boundaries. In the empirical analysis, the paper explores this conflict in three aspects of China's AI policy: (i) AI open-source software as industrial policy, (ii) "picking winners" and the "national team" in AI; and (iii) the limited relevance of the military in AI development.

My findings make several contributions. First, marked by the State Council's publication of a national AI development plan in July 2017, China's AI strategy has drawn much attention from both scholars and policymakers who have tended to focus on research and development (R&D) outlays and preferential support for certain firms.[8] This paper provides an alternative perspective on China's AI policy that emphasizes other aspects. Second, this work contributes to scholarship on China's science and technology policies. A growing literature is taking sectoral distinctions seriously in assessing the effectiveness of Chinese industrial policies.[9] My contribution is that the GPT-ness of a particular technological domain is an essential consideration in evaluating Chinese technology policy. Third, more broadly, there is a large body of literature that studies the interplay of technological change, institutional adaptations, and industrial policy.[10] The study demonstrates that the technological specifics matter and that they could shape the types of institutional adjustments and policies that are most optimal.

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7 Optimality, in this context, refers to the policy objectives of a state in attaining wealth and power (including military strength).

8 Ding 2018.

9 See, for example, Mao et al. 2021.

10 Freeman and Louca 2001; Nelson and Winter 1982; Perez 2002.

II. Theory: The Unique Demands of GPTs for Technology Policy

“AI is the new electricity.” First popularized by Andrew Ng during a speech at Stanford University, the comparison between AI and electricity has become a common refrain for scholars and policymakers alike.[11] Core to this analogy is the general-purpose nature of both technologies. Among studies of technological change and long-term historical economic growth, electricity “is unanimously seen in the literature as a historical example of a GPT.”[12] Forecasting the potential of AI, economists regard AI as the “next GPT”[13] and “the most important general-purpose technology of our era.”[14] As Kevin Kelly, the former editor of *Wired*, once wrote, “Everything that we formerly electrified we will now cognitize…business plans of the next 10,000 startups are easy to forecast: Take X and add AI.”[15]

Singled out by economic historians as “engines of growth,”[16] GPTs are defined by three characteristics. First, they exhibit significant scope for continual improvement. Second, GPTs develop both a wide *variety* and *range* of economic applications. AI, for example, has a wide variety of uses (e.g., object identification, natural language understanding, and prediction) and a wide range of uses (i.e., the breadth of industries that could apply AI). Third, GPTs have strong technological complementarities. In other words, the value of innovations in a GPT only materialize when other linked technologies are changed in response. Shaped by these characteristics, Stanford economist Paul David describes the evolution of a GPT as an extended trajectory of incremental technical improvements, the gradual and protracted process of diffusion into widespread use, and the confluence with other streams of technological innovation, all of which are interdependent features of the dynamic process through which a general purpose engine acquires a broad domain of specific applications.[17]

Comprehending this GPT trajectory is a prerequisite to analyzing how countries can adapt to these foundational breakthroughs. A rich tradition of work on the coevolution of technology and institutions stresses the “goodness-of-fit” between the demands of

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11 A Google search for the exact phrase “AI is the new electricity,” conducted on September 15, 2022, returned over 17,000 results. Ng first popularized this comparison in a 2017 speech at Stanford University.

12 Ristuccia and Solomou 2014, 227.

13 Trajtenberg 2018.

14 Brynjolfsson and McAfee 2017. See also Teece 2018, 1370.

15 Kelly 2014.

16 Bresnahan and Trajtenberg 1995.

17 David 1990, 356.

evolving technologies and a country's institutional and policy responses.[18] New technologies impose demands on governments and institutional arrangements. If the surrounding environment is slow or fails to adapt, the development of emerging technologies is hindered.

Which responses fit the demands of GPTs? Adaptation to GPTs must address a crucial issue. Because the economic value of GPTs is achieved only through improvements across a broad range of industries, extensive coordination between the GPT sector and numerous application sectors is required. Given the sheer breadth of potential applications for a GPT, it is infeasible for innovating firms in the GPT sector to commercialize the technology on their own, as the necessary complementary assets are embedded with different firms and industries.[19] Returning to AI as an example, firms that develop general machine learning algorithms will not have access to all the industry-specific data necessary for fine-tuning algorithms to particular application scenarios.

Therefore, coordination between the GPT sector and other organizations that provide complementary capital and skills, such as academia and competitor firms, is crucial. One tangible form of coordination is the process of standardization, which fosters the diffusion of GPTs by committing application sectors to specific technological trajectories and encouraging complementary innovations.[20] In contrast, for technologies that are *not* general-purpose, this type of coordination is less salient for and even detrimental to a nation's competitive advantage, as the innovating firm could leak its technical secrets.[21]

Notably, these suggested adaptations to GPTs diverge markedly from how recent scholarship characterizes China's industrial policy. Three specific differences stand out. First, a GPT-oriented approach favors open information flows, whereas China's emphasis on indigenous innovation features heavily in general accounts of China's efforts to promote emerging technologies. In particular, Made in China 2025 has been held up as a prime example of China's ambitions to achieve certain self-sufficient targets in industries such as aviation and new energy vehicles.[22]

18 Freeman and Louca 2001; Nelson and Winter 1982; Perez 2002.

19 Gambardella et al. 2021; Teece 2018.

20 Baron and Schmidt 2014; Bresnahan and Trajtenberg 1995; Thoma 2009.

21 Goldfarb et al. 2021.

22 Laskai 2018.

Second, while recent scholarship on China's technology strategy emphasizes direct government interventions that prop up a few national champions, GPT-based policies should prioritize coordination between the GPT sector and a broad range of application industries. When it comes to "picking winners" in specific national industrial policies, Chinese planners often target two or three main firms to achieve a certain level of production capacity.[23] James A. Lewis, who heads the strategic technologies program at the Center for Strategic and International Studies, regards "the promotion of national champions by any means" as an essential part of China's solution for securing core industries.[24]

Third, analysts generally view the People's Liberation Army's involvement as a boon for progress in certain dual-use technologies.[25] The Chinese military's early investment in the Beidou navigation satellite system is largely seen as a crucial part of the system's success.[26] This accords with *some* of the GPT literature. In one study of six technologies, Vernon Ruttan finds that military demand and investment were key sources for generating advances in GPTs.[27]

However, there are many reasons to believe that a GPT-oriented approach should prioritize civilian-led development. As evidenced by the development of electricity in the United States, military procurement may not be necessary for spurring advances in GPTs, because other civilian institutions could serve as strong sources of demand for GPTs.[28] In addition, if the focus is on the gradual spread of GPTs throughout the economy, as opposed to the initial breakthroughs in GPTs, a great deal of evidence suggests that civilian and military needs can greatly conflict.[29] Interestingly, studies of the commercialization of Beidou programs have noted this tendency.[30] As one scholar writes, "if the primary purpose of Beidou is commercialization and national innovation, a military-operated management system—particularly in an opaque organization like the PLA—is hardly the best option…the complicated command and control arrangement within the military has severely hampered commercial application in the past."[31]

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23 Chen and Naughton 2016, 2141–2142

24 Lewis 2018.

25 All GPTs are dual-use, but not all dual-use technologies are GPTs. The diversity of potential applications for many dual-use technologies is limited.

26 Nouwens and Legarda 2018.

27 Ruttan 2006.

28 Brown 2000.

29 Alic et al. 1992, 37–43; Misa 1985.

30 Hagt 2014; Pollpeter et al. 2014.

31 Hagt 2014, 137.

In summary, the theoretical framework suggests that China's approach to promoting GPTs will face a tension between the logic of a GPT-oriented approach and the conventional toolkit it uses to target technologies that can more easily be contained within sectoral boundaries. In the empirical section, this paper explores that tension in three areas of Chinese AI policy: (i) support for AI open-source software, (ii) "picking winners" and the "national team" in AI; (iii) and the role of the military in AI development.

III. Empirics: China's Approach to Promoting AI as a GPT

China's approach to spurring AI development presents good ground to probe the plausibility of the aforementioned theoretical framework. While it is too early to say whether AI qualifies as a GPT on the scale of electricity, several studies have found evidence for a GPT trajectory in AI. One study, using a novel dataset of preprint papers, finds that articles on deep learning conform with a GPT trajectory.[32] Using patent data from 2005–2010 to construct a three-dimensional indicator for the GPT-ness of a technology, Petralia ranks technological classes based on their GPT potential.[33] His analysis finds that image analysis, a field that is closely tied to recent advances in deep learning and AI, ranks among the top technological classes in terms of GPT-ness.[34] Another effort employs online job posting data to differentiate among the GPT-ness of various technological domains, finding that machine learning technologies are more likely to be GPTs than other technologies such as blockchain, nanotechnology, and 3D printing.[35]

To be sure, forecasts of future GPTs also call attention to other technological trends. Other studies have pointed out and verified the GPT potential of biotechnology.[36] Robotics could underpin "the next production system" that will boost economy-wide

32 Klinger et al. 2021.

33 The three dimensions correspond to the three characteristics of GPTs: scope for improvement, the variety of applications to products and processes, and complementarity with existing and new technologies. These are measured by patenting growth rates, a text-mining algorithm that looks for patterns in technology-specific vocabulary, and co-occurrence of claims in patents. Petralia 2020, 9–10.

34 Petralia 2020, 7. Image analysis ranks 6th. The technological classes, based on the U.S. Patent and Trademark Office classification scheme, that rank higher, from highest to lowest, are television, telecommunications, radiant energy, illumination, and electrical communications.

35 Goldfarb et al. 2021.

36 Feldman and Yoon 2012; Ruttan 2001, 368–422.

productivity, succeeding the previous one driven by information technology.[37] While the primary reasons for limiting my analysis to AI are based on space constraints and its prominence in the surrounding literature, it is also important to note that developments in both biotechnology and robotics are becoming increasingly dependent on advances in deep learning and big data.[38]

1. Open Source as Industrial Policy

In March 2021, the phrase "open source" appeared in China's Five-Year Plan (covering the years 2021–2025) for the first time.[39] In a section about promoting the digital economy, the plan stated that China will "support the development of innovative consortia such as digital technology open source communities…encourage enterprises to open up software source code, hardware designs, and application services."[40] This coincides with a wave of government action in open-source software, including support for Gitee, an alternative to the popular developer collaboration platform GitHub.[41]

Chinese planners see open-source software as a foundation for China's AI development. In July 2018, the Ministry of Industry and Information Technology (MIIT) published a White Paper on China's Development of AI Open-Source Software. Bringing together China Electronics Standardization Institute, Baidu, and Peking University, among 60 other contributing groups, this effort mapped out the landscape of AI open-source software and put forward recommendations to improve the overall open-source ecology. Specifically, the White Paper pushed for cultivating a better open-source culture and improving licensing agreements for open-source software.[42] In their analysis of Beijing's embrace of open source as an industrial policy tool, Rebecca Arcesati and Caroline Meinhardt, researchers at the Mercator Institute for China Studies, note, "Open-source collaboration is especially central to China's AI development strategy, which emphasizes the development of platforms where resources are openly shared."[43]

Given the theoretical expectations for GPT-targeted policy responses, the Chinese government's support for AI open-source software is not surprising. Leading firms in AI

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37 Atkinson 2019. Thurbon and Weiss (2019, 2) describe it as "a general purpose technology, with key applications in industrial, personal, and professional service spheres." Empirical estimates confirm the potential of robots as engines of growth. According to one study of seventeen countries from 1993 to 2007, the increased use of industrial robots accounted for 15% of economy-wide productivity growth. Based on this figure, the study's authors conclude that the contributions of robots to productivity growth is comparable to those of GPTs in previous historical periods, such as the steam engine. Graetz and Michaels 2018, 765–766.

38 Oliveira 2019; Pierson and Gashler 2017.

39 An archived version of the Chinese source text is available online at https://perma.cc/73AK-BUW2.

40 Full English translation available here: https://cset.georgetown.edu/publication/china-14th-five-year-plan/.

41 Xu 2020.

42 Ministry of Industry and Information Technology 2018.

43 Arcesati and Meinhardt 2021.

have open-sourced some of their foundational deep-learning frameworks (e.g., Google's TensorFlow and Facebook's PyTorch) as a way to enable the spread of AI at scale. These open information flows help improve coordination between the GPT sector and the diversity of application sectors that will use specialized algorithms built using open-source tools.

Indeed, the Chinese government encourages companies, research organizations, and open-source communities to increase their adoption of AI open-source software. This inevitably requires dependence on a global community of software developers, since the United States is home to 66 percent of the world's AI open-source software developers, as cited in the 2018 AI Open-Source Software White Paper.[44] For their part, Chinese technology companies' participation in global open-source communities has grown exponentially over the past decade, as measured by membership in the Linux Foundation and contributions to projects hosted by the Cloud Native Computing Foundation.[45]

In fact, the increasingly coupled nature of the U.S. and Chinese open-source communities could moderate pressures to develop independent technology ecosystems. To illustrate this possibility, consider the case of Docker, a U.S. company that provides a containerization platform used by many firms in information technology and cloud computing. In August 2020, Docker updated its terms of service to prohibit the use of some of its services from companies on the United States' "entity list," which includes some Chinese technology firms implicated in human rights abuses. Initially, some of the Chinese-language coverage warned that Docker's cut-off would have an impact magnitude similar to if GitHub were disconnected, as many leading Chinese technology firms, including Baidu, Alibaba, Tencent, and Huawei deploy services built using Docker software.[46] However, the leading Chinese open-source community (OSChina) stressed that the open-source version of Docker, which is the version used by most developers, would not be affected by Docker's entity list-related update.[47] As the Linux Foundation reiterated, open-source software is not subject to U.S. export administration regulations.[48]

44 Ministry of Industry and Information Technology 2018.

45 Arcesati and Meinhardt 2021.

46 Xinzhiyuan 2020.

47 OSChina 2020.

48 Linux Foundation 2022.

At the same time, technonationalist impulses toward insulated development still shape China's open-source strategy. MIIT has tried to push the aforementioned Gitee as a homegrown alternative to GitHub.[49] In the context of AI, the China Academy of Information and Communications Technology, a think tank under MIIT, tracks the influence of mainstream AI frameworks such as TensorFlow and PyTorch, which are hosted on GitHub and domestic Chinese frameworks hosted on Gitee.[50] China hopes that Baidu's PaddlePaddle framework and Huawei's MindSpore framework can challenge the TensorFlow-PyTorch duopoly.[51] In this way, Beijing's drive for homegrown, independent strategic technologies also extends to open-source software, because policymakers fear actions that would restrict Chinese developers' access to open-source projects.

Still, these efforts to "nationalize" open-source frameworks have met limited success so far, which may speak to the resilience of cross-border ties in AI software development. Chinese open-source developers largely prefer GitHub to Gitee.[52] Megvii has not even published MegEngine, a highly regarded open-source framework in China, on Gitee.[53] In February 2021, Deloitte, Extreme Mart (a Shenzhen-based AI developer community), and the China Society of Image and Graphics jointly published a "China Computer Vision Talent Survey Report." The report collected 1,578 questionnaire responses from students and researchers in the computer vision field. While over 70 percent of people employed in the computer vision field reported using PyTorch, a popular machine learning framework originally developed by Facebook, only 6.5 percent had used any frameworks developed by Chinese firms and organizations. The corresponding figure was even lower among students in computer vision, with less than 2 percent reporting use of Chinese machine learning frameworks.[54]

The significance of coordinating information flows between innovating firms in the GPT sector and application sectors extends beyond just open-source development in AI. According to one empirical study that collected procurement contracts for 1,095 facial recognition firms in China, access to government data played a crucial role in spurring technology development.[55] In this case, data was the crucial complementary asset that was needed to spread among many actors involved in the GPT trajectory.

49 Xu 2020. For an excellent backstory on Gitee vs. GitHub, see Tobin 2021.

50 China Academy of Information and Communication Technology 2022.

51 China Academy of Information and Communication Technology 2022.

52 Xu 2020.

53 China Academy of Information and Communication Technology 2022.

54 Synced 2021.

55 Beraja et al. 2020.

The development of technical standards in AI could also play an important coordinating role. In particular, Chinese government efforts to encourage the development of standards on AI safety and trustworthiness will go a long way toward the sustainable development of AI across a broad range of sectors.[56]

2. Picking Winners and the National AI Team

For Chinese planners, the approach to "picking winners" in AI differs markedly from other industrial policies that champion two or three main firms. To begin, the number of so-called winners is much larger. In 2017, the Ministry of Science and Technology (MOST) designated four firms—Baidu, Alibaba, Tencent, and iFlytek—as members of a "national team" (*guojiadui*) in AI, tasking them to lead the development of AI open innovation platforms (AIOIPs).[57] By August 2019, the membership of this AI national team had expanded to fifteen firms.[58]

This expanded "national team" roster can be understood in a variety of ways. On one level, the breadth of AI applications across industries could have spurred MOST to promote innovation platforms oriented toward specific subdomains. Given that Xiaomi is a leader in smart home devices, it makes sense that MOST would charge it with building the AI ecosystem in that field. Yet, the national AI team's expansion also reflects the fact that no one company will dominate a particular subdomain of AI development. For instance, MOST tasked new member JD.com, an e-commerce giant, with responsibility for creating an open innovation platform in smart supply chains, but Alibaba will continue to compete for leadership in that domain. When providing updates on the progress of their respective innovation platforms, national team members often report on their efforts in areas that overlap with the domains assigned to other members.[59]

As AI advances have found applications in one industry after another, MOST's approach to the AI national team has evolved toward more inclusivity. In updated guidelines for the construction of national AIOIPs published in August 2019, MOST announced that companies could now apply to join the "team" by selecting a particular subdomain of AI in which they would invest, lowering the barrier of entry for small and medium enterprises.[60] As Benjamin Larsen concludes, "The AIOIP initiative is less about granting

56 Ding et al. 2018.

57 Horowitz et al. 2018.

58 China Securities Journal 2019.

59 Leiphone 2019.

60 China Securities Journal 2019.

preferred access to a few select companies, and more about enabling structural mechanisms that afford greater participation and innovation in emerging ecosystems and sectors that increasingly will be powered by AI technologies."[61]

There is, to be sure, variation in terms of ties to the state among members of the AI national team. CloudWalk Technology, one of China's four leading computer vision companies, has been described as "a member of the national team unlike the others."[62] Unlike other national team members, including competitor facial recognition firms SenseTime and Megvii, CloudWalk is considered a "purely domestically funded" company [纯内资], as much of its financing comes from government funds like the China Internet Investment Fund, which was set up by the Central Cyberspace Affairs Commission and the Ministry of Finance in China. Industry observers note that CloudWalk's background could serve as "a protective screen for some security and financial projects that involve national security," noting that it was one of the only AI firms invited to shape facial recognition standards at the national, public security bureau, and industry levels.[63]

However, in some ways, CloudWalk is the exception that proves the rule. Other computer vision upstarts have much more distance from the state and receive more financing from international sources. Overall, during the period 2014 to 2019, AI was the technology focus area that experienced the largest increase in the frequency of U.S. venture capital investments in China.[64] Moreover, facial recognition providers that are narrowly focused on government and security-based projects may struggle to exploit AI's GPT trajectory. Increasingly, Chinese computer vision firms are trying to reduce their reliance on government surveillance applications and diversify to other sources of revenue in smart finance and commercial retail.[65]

3. The Limited Relevance of Military Support for Dual-Use Technologies

What has been the role of the PLA in supporting China's progress in AI? There are some reasons to believe that military procurement and investment play a necessary role in supporting the development of GPTs like AI. In the broader literature on GPTs, drawing from examples from the U.S. experience during the second half of the 20th century,

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61 Larsen 2019.

62 Synced 2020.

63 Synced 2020.

64 Lysenko et al. 2020.

65 Feng and Xue 2020.

some scholars emphasize military demand as an important driver of GPTs.[66] In studies of Chinese megaprojects in systems with dual-use benefits, such as the Beidou navigation satellite system, the PLA's involvement is largely viewed as an essential factor in the system's successful development.[67]

However, my theoretical framework suggests that military support is not necessary to the widespread adoption of a GPT. The United States' experience with electricity clearly illustrates this point. In the late 19th century, when the United States was a leader in electrification, the amount of money invested in research and development within electrical engineering departments and electric companies across the United States was "many times greater than that invested in all [the United States'] ships put together."[68] One of the clearest demonstrations of how military electrification had to adapt to the civilian electric industry, not the other way around, was the U.S. military's switch from direct current (DC) to alternating current (AC) standards in coastal defense fortifications. Prior to 1898, all U.S. military electrification projects preferred the use of DC, even though civilian industry was transitioning to AC systems. Over time, as expenses of maintaining separate DC power systems for military posts accumulated, U.S. policy adjusted "towards a goal of accommodation with civilian commercial utilities."[69] Ultimately, in adapting AC standards, the United States recognized that widespread military electrification would only be possible if the army permitted the integration of AC systems, which were dominant in commercial electrification.[70]

Unlike in other dual-use domains, the development of AI in China was primarily incubated in the commercial sector. "The locus of innovation in AI has shifted to the private sector," notes Elsa Kania, a leading scholar on Chinese military AI. "Consequently, Chinese leadership seeks to ensure that private sector progress in AI can be rapidly transferred for employment in a military context through a national strategy of military-civil fusion, while building up capability in its defense industrial base."[71] The effectiveness of this transfer will also be shaped by the overall military civil-fusion effort, which has been a protracted process to date.[72]

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66 Ruttan 2001; Ruttan 2006.

67 See, for example, Strickland 2022. For evidence that military influence over the Beidou program hinders commercialization, see Hagt 2014; Pollpeter et al. 2014.

68 Fiske 1886, 424.

69 Brown 2000, 59.

70 Brown 2000, 36-37, 59, 64, 98. See also Fiske 1886, 327.

71 Kania 2017, 19.

72 Cheung 2022.

This is not to say that military R&D and procurement have played no part in spurring China's development of AI. The PLA is a source of demand for some Chinese AI companies—for instance, voice recognition and machine translation for counterintelligence and intelligence processing, as well as video surveillance for border defense and training exercises—and it does conduct some research on unmanned vehicles, which has spillovers to the commercial domain.[73] On the whole, nevertheless, the private sector has driven the development of AI in China.[74]

IV. Conclusion

The unique characteristics of GPTs demand an equally unique approach to science and technology policy. Indeed, China's approach to promoting AI—often regarded as "the next GPT" —include policy and institutional adaptations that mediate other characteristics of Chinese industrial policy. Specifically, this paper shows that China's AI strategy diverges from expectations derived from typical characterizations of China's industrial policy, which stress an emphasis on self-sufficiency, support for a limited number of national champions, and the essential role of military investment and demand for progress in dual-use domains.

Care should be taken with these preliminary findings, and there are numerous limitations to this investigation. AI is still an evolving field, and since many of the studied initiatives have been announced in the last few years, tracking their actual implementation and effectiveness will be crucial. In the future, it is possible that countervailing trends will outweigh the ones identified in this paper.

Due to space and scope limitations, this paper only covered a partial range of AI policies. One notable exception is the lack of consideration for education policy. China's initiative to set up a new AI major at the university level, for instance, marks a departure from other countries' education policies that keep AI within the general computer science major.[75] This links up with broader issues with Chinese technology policy, which tend to prioritize investment in R&D sometimes at the expense of education funding, which is more tied to technology adoption.[76] China's five-year plan (2021–2025) aims to raise basic research spending by over 10 percent in 2021, targeting AI and six other key

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73 Kania 2017, 20.

74 Lee 2018.

75 Synced 2021.

76 Brandt et al. 2020, 20.

technological domains.[77] China consistently sets and meets ambitious targets for R&D spending, but that same commitment has not extended to education funding. One possible explanation for this disparity between attention to R&D versus education is the longer time required for efforts in the latter to yield tangible progress in technological development."[78] Given the fact that longer timelines are especially relevant for the extended trajectory of GPTs, this only elevates the significance of education policy.

All too often, it seems, both technology planners and scholars of industrial policy focus on cornering key market segments through massive R&D investments as the boilerplate goal for any strategic technology.[79] As China transitions from initiating a new GPT trajectory in AI to spreading AI across broad and varied application sectors, increased attention should be paid to other aspects of technology policy more tied to the process of diffusion, such as standardization activities, industry-academia linkages, and those highlighted in this paper. GPTs like AI are not the same as other technologies, and they demand a different toolkit of strategies.

77 Horwitz et al. 2021.

78 Liu et al. 2017, 663.

79 For an analysis of the concept of strategic technologies, see Ding and Dafoe 2021.

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