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Hanna Dohmen[1]

Research Analyst, Center for Security and Emerging Technology, Georgetown University
Nonresident Fellow, Global China Hub, Atlantic Council

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"Made in China 2025—Who is Winning?"

Panel II: "The Next Decade of U.S.-China Tech Competition"

Co-Chair Vice Chair Schriver and Co-Chair Commissioner Kuiken, distinguished Commissioners and staff, thank you for the opportunity to participate in today's hearing. It is an honor to testify alongside the esteemed experts on this panel. I am a research analyst at the Center for Security and Emerging Technology at Georgetown University, where I research U.S.-China technology competition, U.S. semiconductor export controls, the semiconductor supply chain, and China's science and technology (S&T) ecosystem.

Today my testimony will focus on how the Chinese S&T ecosystem is driving innovation in emerging technologies, with a particular focus on (i) the Chinese Academy of Sciences and (ii) implications of U.S. semiconductor export controls, including China's response to these restrictions. I also offer three recommendations for policymakers.

I. The Chinese Academy of Sciences' Role in China's S&T Ecosystem

China's pursuit of technological leadership is a decades-long endeavor that has intensified significantly under President Xi Jinping's leadership. In 2006, former President Hu Jintao launched a national campaign to accelerate indigenous innovation and to reduce China's reliance on foreign technologies, which was formalized in part through the "Medium- to Long-Term Plan for Science and Technology (2006-2020)" (MLP; 国家中长期科学和技术发展规划).[2] This plan set national research priorities, provided R&D funding, and emphasized the importance of "indigenous innovation."[3] The MLP was later reinforced through subsequent policies under President Xi Jinping, including "Made in China 2025" (MIC 2025; 中国制造2025).

[1] The opinions expressed in this testimony are mine only and should not be interpreted as representing those of CSET or the Atlantic Council.

[2] "Outline of the National Medium- and Long-Term Plan for Science and Technology Development" [国家中长期科学和技术发展规划刚要], State Council of the PRC, https://perma.cc/6AE8-BJLY.

[3] Cong Cao, Richard P. Suttmeier, and Denis Fred Simon, "China's 15-year science and technology plan," *Physics Today*, December 2006, https://china-us.uoregon.edu/pdf/final%20print%20version.pdf.

MIC 2025 represents one of China's most comprehensive industrial policy plans to achieve indigenous innovation in ten strategic technology industries.[4] The Plan set out three key milestones: (i) become a major manufacturing power by 2025, (ii) become a global manufacturing power by 2035, and (iii) become a leading manufacturing superpower by 2049.[5] While public discussion of MIC 2025 in China has diminished since 2018, the core objectives remain central to the country's industrial policy and efforts to achieve self-reliance in core technology areas, including semiconductors and artificial intelligence (AI).[6]

The Chinese Academy of Sciences (CAS), in part, is tasked with helping realize the objectives of the MLP, MIC 2025, and subsequent policies.[7] Moreover, it serves as an illuminating case study for understanding how China's state-led innovation ecosystem operates and the level of interconnectedness among its research, commercialization, and policymaking efforts.

CAS is directly managed by the State Council, and its primary responsibilities include advancing China's S&T research capabilities in order to strengthen the national innovation ecosystem and boost the country's technological self-reliance. Since its establishment in 1949, CAS has been instrumental in China's technological advancement, contributing to strategic weapon, space technology, and long-range missile development.[8] CAS oversees 115 research institutes, employs over 60,000 researchers, manages two universities, and has an annual budget of around $23.5 billion.[9] CAS has three key functions: (a) advancing research, (b) commercializing technologies, and (c) shaping Chinese S&T policy.

a. Advancing Research

CAS has emerged as China's most prolific producer of STEM research and has become increasingly competitive on the global stage. CAS institutes now lead all other global research institutions in highly cited STEM papers, with particular strength in the industrial technology

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[4] The ten strategic technology industries are: (1) new generation IT, (2) high-end computerized machines and robots, (3) aviation and aerospace equipment, (4) maritime engineering equipment and high-tech ships, (5) advanced rail transportation equipment, (6) new energy vehicles, (7) energy equipment, (8) agricultural machinery and equipment, (9) new materials, and (10) biotechnology, pharma, and high-performance medical devices. PRC State Council, "Notice of the State Council on the Publication of Made in China 2025" [国务院关于印发《中国制造2025》的通知], trans. CSET (CSET, March 8, 2022), https://cset.georgetown.edu/wp-content/uploads/t0432_made_in_china_2025_EN.pdf.

[5] PRC State Council, "Notice of the State Council on the Publication of Made in China 2025."

[6] Alexander Brown and Andreas Mischer, ""Manufacturing Champions" + Equipment renewal + Mobile Internet of Things," MERICS, October 2, 2024, https://merics.org/en/merics-briefs/manufacturing-champions-equipment-renewal-mobile-internet-things.

[7] Richard P. Suttmeier, Cong Cao, and Denis Fred Simon, "'Knowledge Innovation' and the Chinese Academy of Sciences," Science 312, no. 5770 (April 7, 2006): 58–59.

[8] Cole McFaul, Hanna Dohmen, Sam Bresnick, and Emily Weinstein, "Fueling China's Innovation: The Chinese Academy of Sciences and Its Role in the PRC's S&T Ecosystem," CSET, October 2024, https://cset.georgetown.edu/publication/fueling-chinas-innovation-the-chinese-academy-of-sciences-and-its-role-in-the-prcs-st-ecosystem/.

[9] CAS, "Chinese Academy of Sciences 2022 Budget" [中国科学院 2022 年部门预算], trans. CSET (CSET, February 27, 2024) https://cset.georgetown.edu/wp-content/uploads/t0585_CAS_budget_2023_EN.pdf; McFaul, Dohmen, Bresnick, and Weinstein, "Fueling China's Innovation."

field of study.[10] In 2021, 35 percent of papers published by CAS institutes focused on the field of industrial technology.[11] Within this field, CAS institutes published most frequently in the subfield of automation and computer technology, which includes AI-related research, followed by radio electronics and telecommunications technology, and chemical engineering (see Appendix).[12] The number of highly cited STEM papers from CAS institutes has more than doubled between 2012 and 2022, while the number of highly cited CAS researchers has grown from fewer than 40 in 2014 to over 200 in 2022.[13] While bibliometric data is an imperfect proxy for impact, this change nonetheless reflects a notable increase in China's research output and quality.

b. Fostering Commercialization

One of the core functions of CAS is to commercialize technologies that arise from its research. The organization plays an important role in contributing to the development of Chinese technology companies and working toward self-sufficiency in emerging technologies.[14]

The centrality of commercialization to CAS's mission today is evidenced by CAS's 13th Five-Year Plan (2016-2020).[15] The plan stipulates that over the five-year period, the organization will incubate more than 5,000 companies, strengthen globally competitive enterprises and "hidden champion" enterprises, and provide technology development and consulting services for at least 20,000 companies.[16]

One of the main mechanisms by which CAS works to advance technological progress is through investing in research teams at its institutes, universities, and labs. Some of China's most well-known technology companies are spin-offs from CAS research institutes and universities, which CAS supported financially, including Lenovo and iFLYTEK.[17] CAS has various financial institutions that support its commercialization efforts, including asset management firms, venture capital (VC) firms, and university and research institute investment arms.

For instance, Chinese Academy of Sciences Holding Co. (中国科学院控股有限公司; CASH) is CAS's primary asset management firm, which invests in a broad range of S&T fields. Over the last decade, CASH has provided funding for and invested in a number of key Chinese technology companies at various stages of the startup life cycle, from the seed stage to the exit phase. For example, in 2014, together with CAS-spin off and supercomputer manufacturer Sugon, CASH

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[10] In a CSET report titled "Fueling China's Innovation: The Chinese Academy of Sciences and Its Role in the PRC's S&T Ecosystem," we defined highly cited papers as papers in at least the 90th percentile of citations in their field in a given year; McFaul, Dohmen, Bresnick, and Weinstein, "Fueling China's Innovation."
[11] CAS research institutes are the organization's network of research centers conducting basic and applied research across a variety of critical fields in science and technology.
[12] McFaul, Dohmen, Bresnick, and Weinstein, "Fueling China's Innovation."
[13] McFaul, Dohmen, Bresnick, and Weinstein, "Fueling China's Innovation."
[14] McFaul, Dohmen, Bresnick, and Weinstein, "Fueling China's Innovation."
[15] CAS, "Outline of the Chinese Academy of Sciences 13th Five-Year Development Plan" [中国科学院'十三五'发展规划纲要], trans. CSET (CSET, October 17, 2022), https://cset.georgetown.edu/wp-content/uploads/t0454_CAS_13th_5YP_EN.pdf.
[16] CAS, "Outline of the Chinese Academy of Sciences 13th Five-Year Development Plan."
[17] McFaul, Dohmen, Bresnick, and Weinstein, "Fueling China's Innovation."

provided seed funding for Hygon, a Chinese CPU design company.[18] This demonstrates that successful spin-off companies also reinvest in the CAS ecosystem and support other promising companies.

CAS additionally operates a number of VC arms, including CAS Investment Management Co. (中国科技产业投资管理有限公司) and CAS Star (中科创星).[19] CAS Investment Management Co. primarily makes early- and late-stage VC investments in emerging technologies, including biotechnology, AI, and semiconductors.[20] CAS Star appears to be one of the most active CAS investors, which focuses on early-stage investments in emerging technologies as well. CAS Star not only provides investment opportunities, but it is also committed to integrating those early-stage investments with research institutions and post-investment services.[21] As of April 2024, CAS Star managed four funds and invested in more than 470 technology companies, including Zhipu AI, one of China's leading AI startups.[22]

CAS universities and individual research institutes have their own investment arms that support their organization's commercialization endeavors. The University of Science and Technology of China (USTC) manages an investment arm called USTC Holdings Co., which manages the university assets and funds startups. For example, in 2019, USTC Holdings provided VC funding for Origin Quantum, which is a quantum computing startup founded by researchers from USTC.[23] Similarly, the CAS Institute of Computing Technology also manages an investment arm, which has helped the institute launch a number of China's computing and semiconductor companies, including Sugon, Cambricon, and CPU-designer Loongson.[24]

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[18] "Leading Chinese CPU Firm Hygon Listed to Shanghai's STAR Market," Pandaily, August 12, 2022, https://pandaily.com/leading-chinese-cpu-firm-hygon-listed-to-shanghais-star-market/; The U.S. Department of Commerce's Bureau of Industry and Security (BIS) added both Sugon and Hygon to the Entity List in 2019; BIS, "Addition of Entities to the Entity List and Revision of an Entry on the Entity List," *Federal Register* 84 FR 29371 (June 24, 2019), https://www.federalregister.gov/documents/2019/06/24/2019-13245/addition-of-entities-to-the-entity-list-and-revision-of-an-entry-on-the-entity-list.

[19] McFaul, Dohmen, Bresnick, and Weinstein, "Fueling China's Innovation;" "About CAS Star" [关于中科创星], CAS Star, https://archive.ph/t6BKO.

[20] McFaul, Dohmen, Bresnick, and Weinstein, "Fueling China's Innovation."

[21] "About CAS Star."

[22] "About CAS Star;" BIS added Zhipu AI to the Entity List in 2025; BIS, "Addition of Entities to and Revision of Entry on the Entity List," *Federal Register* 90 FR 4617 (January 16, 2025), https://www.federalregister.gov/documents/2025/01/16/2025-00704/addition-of-entities-to-and-revision-of-entry-on-the-entity-list.

[23] Li Xiaoyang, "NPC deputy contributes to quantum computing research," Beijing Review, March 04, 2023, https://www.bjreview.com/Special_Reports/2023/NPC_CPPCC_Sessions_2023/From_the_Magazine/202303/t20230306_800324282.html.

[24] McFaul, Dohmen, Bresnick, and Weinstein, "Fueling China's Innovation;" BIS added ICT to the Entity List in 2022, Loongson in 2023, and USTC in 2024; BIS, "Additions and Revisions to the Entity List and Conforming Removal From the Unverified List," *Federal Register* 87 FR 77505 (December 19, 2022), https://www.federalregister.gov/documents/2022/12/19/2022-27151/additions-and-revisions-to-the-entity-list-and-conforming-removal-from-the-unverified-list; BIS, "Additions and Revisions of Entities to the Entity List," *Federal Register* 88 FR 13675 (March 6, 2023), https://www.bis.doc.gov/index.php/documents/regulations-docs/federal-register-notices/federal-register-2023/3245-88-fr-13673/file; BIS, "Additions of Entities to the Entity List," *Federal Register* 89 FR 41886 (May 14, 2024), https://www.federalregister.gov/documents/2024/05/14/2024-10485/additions-of-entities-to-the-entity-list.

Beyond providing funding for tech enterprises, CAS provides other services designed to promote company development through joint research projects, talent development programs, shared personnel and facilities, access to technical expertise, and other intangible benefits. For instance, the Legend Institute (联想学院), an organization set up between CAS and Lenovo, focuses on exploring S&T training programs and industry-academic-research institute (产学研) integration.[25] To further promote such integration, CAS also constructed various "Technological Innovation and Industrialization Alliances" ("技术创新与产业化联盟"), including the "Advanced Computing Alliance" ("先进计算技术联盟"). This alliance is focused on combining the resources of Sugon and seven CAS research institutes to promote Sugon's competitiveness in high-performance computing and cloud computing.[26]

These examples illustrate how CAS not only promotes S&T research but also fosters commercialization of technologies through an interconnected network and maintains close connections with successful CAS spin-offs that feed back into the Chinese research ecosystem.

c. Shaping and Implementing S&T Policy

CAS has played an important role in shaping and implementing some of China's most significant S&T policy initiatives, and the central government considers CAS to be a key advisory body on innovation policy.[27] The organization played a crucial role in establishing the 863 Program (National High-Tech Development Plan), which advanced progress in supercomputing and aerospace technologies, and the 973 Program, which provided essential funding for basic research until its integration into China's National Key R&D Program in 2016. [28]

The influence of CAS extends beyond direct policy formation through its network of academicians (院士) and associated think tanks. The Chinese Academy of Sciences Academic Divisions (CASAD; 中国科学院学部), established in 1955, serves as a key advisory body to the State Council and other government agencies on S&T policy formation and coordination. Since 2019, CASAD has conducted joint research with the National Natural Science Foundation of China (NSFC) to study development paths for emerging technologies critical to China's development goals.

Additionally, in 2016, CAS founded the Institutes of Science and Development (CASISD; 中国科学院科技战略咨询研究院), which is focused on supporting academicians and providing strategic consultations to the central government by integrating CAS research resources.[29] This organization is intended to improve China's S&T policymaking capabilities.[30]

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[25] CAS, "Outline of the Chinese Academy of Sciences 13th Five-Year Development Plan;" "中国科学院联想学院," Baidu, https://perma.cc/H5EC-975B.
[26] "先进计算技术联盟," CAS Holdings, October 21, 2015, https://perma.cc/K8KB-FREG.
[27] Xiaoxuan Li, Kejia Yang, and Xiaoxi Xiao, "Scientific Advice in China: The Changing Role of the Chinese Academy of Sciences," Nature, July 12, 2016, www.nature.com/articles/palcomms201645.
[28] McFaul, Dohmen, Bresnick, and Weinstein, "Fueling China's Innovation."
[29] Li, Yang, and Xiao, "Scientific Advice in China: The Changing Role of the Chinese Academy of Sciences."
[30] "National High-End Think Tank Construction Pilot Project" [国家高端智库建设试点], China Development Institute, accessed January 23, 2024, https://perma.cc/JA9N-NUXU.

CAS, an interconnected research, commercialization, and policymaking organization, is a useful model for understanding China's state-led innovation ecosystem and its implementation of policies such as MIC 2025. This model, undoubtedly, has led to significant innovation successes, but it has also been plagued by inefficiencies. To what extent China will continue to make scientific and technological advancements remains uncertain. What is certain, however, is that China's innovation capacity should not be underestimated.

II. Effectiveness of Slowing China's Technological Progress Through Export Controls

China's highly-centralized approach to achieving technological self-sufficiency is epitomized by institutions like CAS and supported by massive state investment. It was against this backdrop that the United States began to restrict Chinese access to U.S. technologies, know-how, and capital. The United States has implemented various economic security tools aimed at maintaining U.S. technological leadership, particularly in AI and semiconductors. Export controls emerged as the primary tool for slowing China's military modernization and technological development efforts in recent years. Note that by themselves, export controls only serve to delay—not prevent—China's technological advancement. To achieve the goal of maintaining (and growing) U.S. technological leadership, export controls must be accompanied by concerted efforts to accelerate American innovation. This way, when China does catch up to current U.S. technology levels, we have already moved on to the next technological breakthrough.[31]

At a high level, regulations are being used to restrict both advanced chips used in the development of AI models, in particular large language models (LLMs), and the semiconductor manufacturing equipment used to make those chips from being exported to China. Between 2022 and 2024, the Biden administration issued annual regulatory updates to strengthen restrictions, close gaps, and adjust policies as the technologies advanced.[32]

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[31] Hanna Dohmen, Jacob Feldgoise, and Charles Kupchan, "The Limits of the China Chip Ban," *Foreign Affairs*, July 24, 2024, https://www.foreignaffairs.com/china/limits-china-chip-ban.

[32] The focus of this written testimony is on the annual updates to the advanced computing and semiconductor manufacturing equipment rules. It does not cover the Framework for Artificial Intelligence Diffusion issued on January 15, 2025 because it has not yet taken effect. If and when it takes effect will be determined by the Trump administration; BIS, "Implementation of Additional Export Controls: Certain Advanced Computing and Semiconductor Manufacturing Items; Supercomputer and Semiconductor End Use; Entity List Modification," *Federal Register* 87 FR 62186 (October 13, 2022), https://www.federalregister.gov/documents/2022/10/13/2022-21658/implementation-of-additional-export-controls-certain-advanced-computing-and-semiconductor; BIS, "Implementation of Additional Export Controls: Certain Advanced Computing Items; Supercomputer and Semiconductor End Use; Updates and Corrections," *Federal Register* 88 FR 73458 (October 25, 2023), https://www.federalregister.gov/documents/2023/10/25/2023-23055/implementation-of-additional-export-controls-certain-advanced-computing-items-supercomputer-and; BIS, "Export Controls on Semiconductor Manufacturing Items," *Federal Register* 88 FR 73424 (October 25, 2023), https://www.federalregister.gov/documents/2023/10/25/2023-23049/export-controls-on-semiconductor-manufacturing-items; BIS, "Foreign-Produced Direct Product Rule Additions, and Refinements to Controls for Advanced Computing and Semiconductor Manufacturing Items," *Federal Register* 89 FR 96790 (December 5, 2024), https://www.federalregister.gov/documents/2024/12/05/2024-28270/foreign-produced-direct-product-rule-additions-and-refinements-to-controls-for-advanced-computing.

Whether export controls will be effective at achieving their desired outcomes is a complicated question. Too often it is portrayed as a binary answer, but the reality is that the story is much more complex. I attempt to disentangle some of the overlapping layers below, recognizing that this is a simplified snapshot of an emerging, complicated picture. Moreover, it is worth noting that export controls are designed to impose a strategic delay and increase the costs of China's self-sufficiency efforts.[33] Export controls cannot be expected to prevent all AI development and innovation in China. Therefore, making assessments of the effectiveness of export controls requires a wide-angle lens, not a microscope.

Under the Biden administration, the controls had two distinguishable objectives. First, the U.S. government sought to slow the PLA's modernization capabilities. Second, the U.S. government sought to slow China's development of AI and thereby maintain U.S. technological superiority. Whether the controls will be effective, however, depends on which objective is in focus.

a. Slowing China's Military Modernization

In terms of slowing Chinese military modernization, the controls' impact appears limited for a number of reasons. First, most current weapons systems rely on mature, well-tested chips manufactured using less advanced equipment, which are not subject to current restrictions.[34] Second, not all AI technologies are as compute-intensive as large language models (LLMs). In fact, computer vision models, used for surveillance and threat detection, require less compute than LLMs. Third, while advanced chips do have some military applications—and may have more in the future, particularly in areas like AI-enabled decision making and data processing—the PLA's computing needs can largely be met through a combination of legally imported lower-performing chips, domestically produced chips, and smuggled chips.

The controls could force the Chinese government to devote more resources to diverting controlled chips to China or training LLMs on less advanced chips, thereby driving up the costs of military modernization. However, the Chinese government has a proven track record of expending the resources needed to pursue its strategic objectives. Ultimately, it will be very difficult for export controls to substantially slow the PLA's development and adoption of AI.

b. Slowing China's AI Development and Deployment

The impact of export controls on China's AI advancement presents an even more complex picture, but one that is likely to be more consequential. While China is making progress in pushing frontier AI development and gaining international recognition for its progress, it is too soon to judge whether export controls will be effective. Currently, some of China's most advanced models are still using U.S.-made chips, whether legally imported chips below the export control thresholds, ones that companies stockpiled before controls went into effect, or

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[33] Emily S. Weinstein, "Testimony before the U.S.-China Economic and Security Review Commission Hearing on "Challenges from Chinese Policy in 2022: Zero-COVID, Ukraine, and Pacific Diplomacy," Center for Security and Emerging Technology, August 3, 2022, https://cset.georgetown.edu/publication/emily-weinsteins-testimony-before-the-u-s-china-economic-and-security-review-commission-2/.

[34] "Large Investments by Aerospace and Defense Industries in Microelectronics Are the New Normal," Sourceability, February 14, 2024, https://perma.cc/T6JU-5T7Y.

illegally imported chips.[35] However, stockpiles of chips that China legally imported before U.S. controls took effect will likely last them for the next few years. That is likely when the controls will start to bite more significantly, increasing the gap between the quantity and quality of AI chips available inside and outside of China. Assuming that compute scaling laws—the idea that more compute leads to improved model performance—hold for the foreseeable future, China's demand for chips to develop and deploy AI will likely outstrip its domestic AI chip manufacturing progress by that time.

However, ensuring that efforts to slow China's AI development and deployment succeed will depend highly on the effectiveness of export controls on chip manufacturing tools. Currently, U.S. and allied controls on semiconductor manufacturing equipment are likely more effective than the controls on chips themselves, in part because of the Biden administration's multilateral approach. The United States, together with the Netherlands and Japan, have imposed strict controls on the equipment needed to manufacture advanced-node chips. To be sure, Chinese chip designers like Huawei's HiSilicon have made progress in chip design, and Chinese chip manufacturers have demonstrated an ability to fabricate 7nm chips, albeit at production yields far below industry standards.[36] However, their fabrication capabilities remain heavily dependent on foreign equipment. Similar to the stockpiles of AI chips that Chinese companies built up prior to the controls, Chinese semiconductor manufacturing companies also stocked up on semiconductor manufacturing equipment before allied controls were implemented.[37] This, once again, imposes a lag between when the controls were implemented and when the controls will bite.

c. China's Response

As shown above, the Chinese government's push for self-sufficiency in the semiconductor industry predates U.S. export controls. Given the billions of dollars in investments, public-private partnerships, and other government initiatives aimed at fostering self-sufficiency, China's domestic semiconductor industry was poised to make progress. However, prior to U.S. export controls on China's semiconductor industry, the Chinese government fought against the strong pull of commercial incentives. Chinese fabrication plants preferred to use more sophisticated and reliable equipment from abroad, Chinese designers preferred to manufacture their chips at the best plants in Taiwan and South Korea, and Chinese consumers preferred to use the highest-performance chips designed by Nvidia and other foreign firms.

Now, by limiting China's access to foreign-made chips and equipment to make chips, export controls are creating increased demand for indigenous Chinese equipment, fabrication capacity, and AI chips. This is putting pressure on Chinese companies to invest in domestic industry and join forces with their domestic partners to try to break through key chokepoints in the semiconductor supply chain. These market conditions drive revenue to domestic firms, which will in turn allow these companies to invest more in research and development.

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[35] "DeepSeek-V3 Technical Report," DeepSeek, https://github.com/deepseek-ai/DeepSeek-V3/blob/main/DeepSeek_V3.pdf.
[36] Jacob Feldgoise and Hanna Dohmen, "Pushing the Limits: Huawei's AI Chip Tests U.S. Export Controls," Center for Security and Emerging Technology, June 17, 2024, https://cset.georgetown.edu/publication/pushing-the-limits-huaweis-ai-chip-tests-u-s-export-controls/.
[37] Jacky Wong, "China Is Stockpiling for Next Phase of the Chip Wars," *The Wall Street Journal*, February 26, 2024, https://www.wsj.com/finance/stocks/china-is-stockpiling-for-the-next-phase-of-the-chip-wars-3a5b2af6.

Moreover, Chinese companies are pursuing several technical strategies to overcome restrictions. In chip manufacturing, companies are increasingly turning to chiplet packaging, connecting multiple less powerful chips to create higher-performing packages capable of training and using AI models.[38] This approach helps reduce design and manufacturing costs while working within current technical constraints.

In the AI domain, Chinese AI companies have demonstrated significant progress in LLM training, as evidenced by DeepSeek's latest open-source model.[39] DeepSeek researchers have shown success in optimizing chip-to-chip communication and innovating training methods to effectively train an advanced reasoning model on limited hardware.[40] This suggests that Chinese AI companies could continue to push AI advancements using such engineering techniques, potentially undermining the controls on chips.

d. Multilateral Approach to Export Controls

It is undisputed that export controls are most effective when implemented multilaterally. The U.S. export control strategy under the Biden administration was enhanced by successful multilateral coordination with key allies, particularly Japan and the Netherlands. As the export control strategy becomes more important in managing the geopolitical implications of AI development, so does allied buy-in. However, the current approach, one centered on diplomatic leverage and rule-by-rule persuasion, is unlikely to be sustainable or effective in the long-run. In order for the broader U.S. export control strategy to work, it is critical that the United States clearly articulates the objectives of the export controls to allies, provides evidence that justifies the objectives, and underscores why they are necessary to protect *common* interests.

Export controls have traditionally been used to control the development, production, and use of a weapon. As Kevin Wolf has pointed out to the Commission previously, the messaging thus far has fallen short of articulating and convincing some allies of the identifiable relationship between the controls on chips and semiconductor manufacturing equipment and the risk downstream technologies like AI pose.[41] Further work must be done to provide evidence and systematically engage with allies on why such controls are needed.

III. Recommendations for Future U.S. Policy

China's whole-of-nation approach to innovation and technology development, exemplified by institutions like CAS, demonstrates both the scale and sophistication of its technological

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[38] Jane Lee and Eduardo Baptista, "Chip wars: How 'chiplets' are emerging as a core part of China's tech strategy," July 13, 2023, https://www.reuters.com/technology/chip-wars-how-chiplets-are-emerging-core-part-chinas-tech-strategy-2023-07-13/.
[39] "DeepSeek-V3 Technical Report."
[40] "DeepSeek-V3 Technical Report."
[41] Kevin Wolf, "Testimony before the US-China Economic and Security Review Commission Hearing on Key Economic Strategies for Leveling the US-China Playing Field: Trade, Investment, and Technology," Center for Security and Emerging Technology, May 23, 2024, https://www.uscc.gov/sites/default/files/2024-05/Kevin_Wolf_Testimony.pdf.

ambitions. While U.S. export controls may temporarily slow and impose costs on China's AI advancement, they are unlikely to significantly impede its military modernization. Although the United States currently maintains a competitive advantage in semiconductor technology and AI, China's demonstrated innovation capabilities suggest this lead is not guaranteed. Understanding China's innovation ecosystem and how it mobilizes resources, like CAS, to drive national policies is therefore critical. Moving forward, it is important that the United States complement its strategy of restricting technology, capital, and know-how to China with investments in domestic technology development to maintain U.S. technological superiority in the long run.

To conclude, I offer three recommendations for policymakers:

1. **Strengthen Evidence-Based Assessments of China's Technological Progress**

To write effective regulations, U.S. policymakers need accurate, evidence-based assessments of China's technological progress. The United States should enhance its open-source intelligence (OSINT) collection and analysis capabilities to help augment the government's understanding of China's S&T ecosystem and monitor progress in semiconductor technology and AI.[42] As CSET researchers have recommended before, establishing a new, open-source science and technology focused research center would help monitor global developments in emerging technologies and their implications for U.S. national and economic security.[43]

2. **Require the Department of Commerce to Conduct Scenario Planning of Export Control Policies**

Congress should require the Department of Commerce to institute scenario planning exercises before implementing new export controls. These exercises should include clear articulations of control objectives, analyses of underlying assumptions, assessments of economic impact on U.S. and allied firms, evaluations of potential Chinese countermeasures and adaptations, and considerations of near- and long-term consequences. Additionally, BIS should conduct regular post-implementation assessments that track progress toward stated control objectives, impact on China's semiconductor manufacturing equipment industry, developments in China's semiconductor fabrication capabilities, and advancements in China's AI sector.

To support these expanded responsibilities, Congress should increase funding for BIS to expand analytical and enforcement capabilities, strengthen monitoring and compliance programs, enhance coordination with international partners, and improve technical expertise in emerging technologies. These requirements would ensure more strategic and effective implementation of export controls as well as continued evaluation and monitoring of controls while providing Congress with better oversight of their impact and effectiveness.

[42] Owen J. Daniels, "CSET Analyses of China's Technology Policies and Ecosystem: The PRC's Efforts Abroad," (CSET, September 2023), https://cset.georgetown.edu/publication/the-prcs-efforts-abroad/.
[43] Daniels, "CSET Analyses of China's Technology Policies and Ecosystem: The PRC's Efforts Abroad."

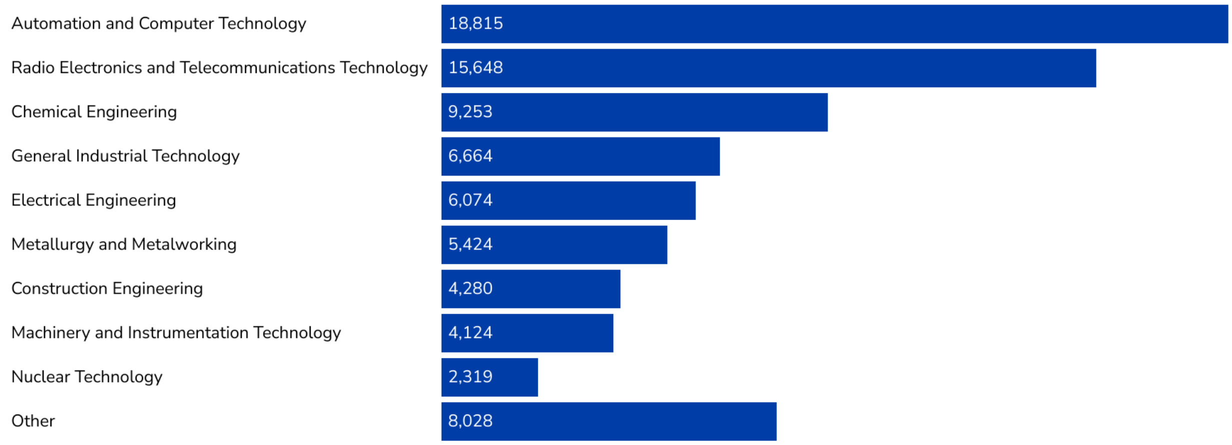
3. Invest in U.S. Technology Progress

Driving innovation domestically should be the top priority of U.S. policy when it comes to competing with China. The bottom line is that the U.S government ultimately has only a limited capability to obstruct China's technological advance on a level that will be geopolitically consequential. What U.S. policymakers can significantly influence, and where they should focus their efforts, is on the United States' own innovation capacity. The United States must drive innovation in the next generation of emerging technologies by funding basic research, expanding workforce development programs, and investing in the domestic manufacturing ecosystem.

Congress has a crucial role to play in shaping this approach through legislation that supports domestic innovation and promotes the development of next-generation technologies. By taking action in these areas, Congress can help ensure that the United States maintains its technological leadership while effectively managing the challenges posed by China's technological advancement.

IV. Appendix

Figure 1: CAS Institutes Industrial Technology Papers by Subfield, 2010-2021



Source: CNKI[44]

[44] Figure 5 in CSET Report "Fueling China's Innovation: The Chinese Academy of Sciences and Its Role in the PRC's S&T Ecosystem;" McFaul, Dohmen, Bresnick, and Weinstein, "Fueling China's Innovation."