Chapter 12: Intellectual Property

Intellectual Property Policy is a National Security Priority

Issue Executive Order on IP for AI and Emerging Technologies.

Develop Plan to Reform and Establish IP Policies and Regimes.

Assess "IP Considerations."

Propose Executive and Legislative Actions.

Integrate into National Security, Economic, and Technology Competitiveness Strategies.

China is both leveraging and exploiting intellectual property (IP) policies as a critical tool within its national strategies for emerging technologies. The United States has failed to similarly recognize the importance of IP in securing its own national security, economic interests, and technology competitiveness. The U.S. has not developed comprehensive IP policies to incentivize investments[1] in and protect the creation of artificial intelligence (AI) and other emerging technologies.[2] The consequence of this policy void—which includes legal uncertainties created by current U.S. patent eligibility and patentability doctrine, the lack of an effective response to China's domestic and geopolitical strategies centered on its IP institutions,[3] and the lack of effective data protection policies—is that the U.S. could lose its prime position in IP global leadership. At the same time, by strengthening its IP regimes,[4] China is poised to "fill the void" left by weakened U.S. IP protections, particularly for patents, as the U.S. has lost its "comparative advantage in securing stable and effective property rights in new technological innovation."[5] This stark policy asymmetry has multiple significant domestic and international implications for the U.S.

First, U.S. courts have severely restricted what types of computer-implemented and biotech-related inventions can be protected under U.S. patent law.[6] Critical AI and biotech-related inventions have been denied patent protection since 2010.[7] Facing uncertainty in obtaining and retaining patent protection, inventors pursue trade secret protection. Trade secrets do not readily promote innovation markets, because trade secrets, unlike patents, do not contribute to accessible technical knowledge in the public domain.[8] While these impacts might not be immediate, the long-term effects on AI and other emerging technology developments and competitiveness are concerning.[9]

Second, China has met its strategic policy goal of increasing the quantity of its patent applications and issued patents, creating the narrative that it has "won" the innovation race. In 2019, the total number of "invention" patent applications filed at the China National Intellectual Property Administration (CNIPA) was approximately three times as many as utility patent applications filed at the U.S. Patent and Trademark Office (USPTO).[10] China also led the world in international patent applications under the Patent Cooperation Treaty (PCT) system of the World Intellectual Property Organization (WIPO).[11] Critically, China is now frequently identified as the current leader in domestic patent application filings for AI inventions.[12] Globally, AI patent applications originating from China outnumber those originating from the United States, especially in recent years.[13]

"The U.S. has not developed comprehensive IP policies to incentivize investments in and protect the creation of AI and other emerging technologies. The consequence of this policy void ... is that the U.S. could lose its prime position in IP global leadership."

China IP Trends.

China's National IP Regimes for AI and Emerging Technologies

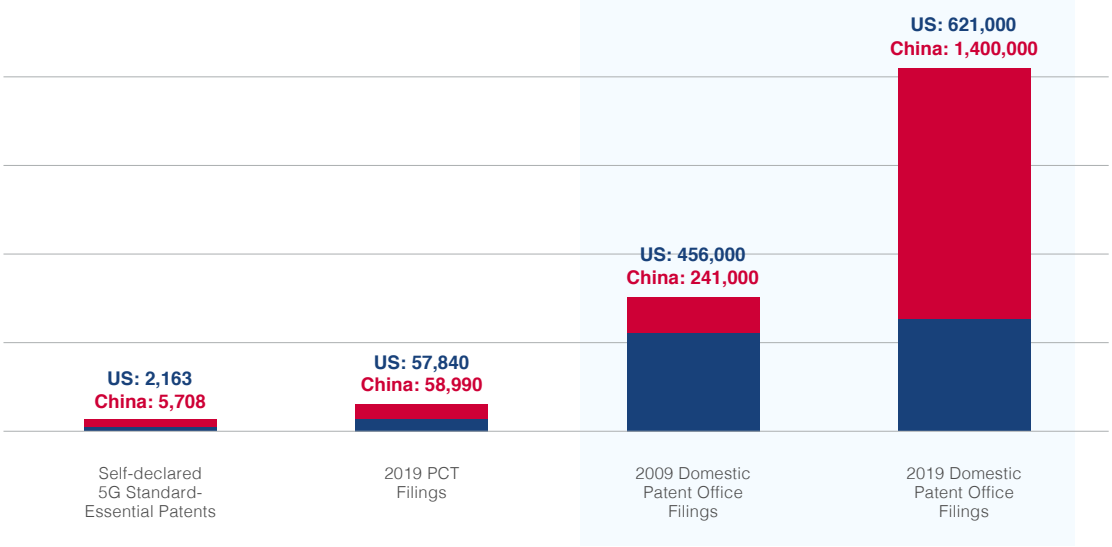
National 13th Five-Year Plan for the Development of Strategic Emerging Industries articulates IP-related goals for emerging technologies:

- Revising the Patent Law and Copyright Law
- Strengthening IP rights protections through rapid rights protection centers
- Developing strategic advancement plans for IP rights of emerging technologies
- Improving overseas IP rights and supporting companies involved in overseas M&A

Patent filings are incentivized by:

- Patent subsidies
- Rewards for granted patents
- Patent quotas set by provincial or municipal governments
- Preferential treatment in government procurement processes for companies with Chinese IP

Patent protection is increased through preliminary injunctions for patent infringement, increases in punitive damages for IP infringement (allows for quintuple damages for willful infringement), and specialized IP courts with efficient resolution and low litigation costs.



CSET Translation of *National 13th Five-Year Plan for the Development of Strategic Emerging Industries*, Central Committee of the Communist Party of China and the PRC State Council (Published Nov. 29, 2016) (translation by CSET on Dec. 9, 2019), https://cset.georgetown.edu/research/national-13th-five-year-plan-for-the-development-of-strategic-emerging-industries//; Eric Warner, *Patenting and Innovation in China: Incentives, Policy, and Outcomes*, RAND at 17-18 (Nov. 2014), https://apps.dtic.mil/dtic/tr/fulltext/u2/a619128.pdf; *Trademarks and Patents in China: The Impact of Non-Market Factors on Filing Trends and IP Systems*, U.S. Patent and Trade Office (Jan. 2021), https://www.uspto.gov/sites/default/files/documents/USPTO-TrademarkPatentsInChina.pdf; Ryan Davis, *4 Things to Know About China's Revised Patent Law*, Law 360 (Nov. 5, 2020), https://www.law360.com/articles/1326419/; Justice Tao Kaiyuan, *China's Commitment to Strengthening IP Judicial Protection and Creating a Bright Future for IP Rights*, WIPO Magazine (June 2019), https://www.wipo.int/wipo_magazine/en/2019/03/article_0004.html.

Note: The self-declared 5G standard-essential patent numbers are as of February 2020 and represent the combined total from the two companies that are the largest filers in each country. For the United States, 2,163 represents the 1,293 applications filed from Qualcomm and 870 filed from Intel. For China, 5,708 represents the 3,147 filed from Huawei and 2,561 filed from ZTE. This number also represents the standard-essential patents filed, not the number of patents granted. See Jed John Ikoba, *Huawei Has Filed the Most 5G Patents Globally as of February 2020 - Report*, Gizmochina (June 2, 2020), https://www.gizmochina.com/2020/06/02/huawei-has-the-most-5g-standard-essential-patents-globally/; *China Becomes Top Filer of International Patents in 2019 Amid Robust Growth for WIPO's IP Services, Treaties and Finances*, WIPO Media Center (Apr. 7, 2020), https://www.wipo.int/pressroom/en/articles/2020/article_0005.html; For the domestic patent office filings, according to the China National Intellectual Property Administration (CNIPA), "the number of invention patent applications it received increased by more than 500 percent between 2009 and 2019, from 241,000 to 1.4 million (although, interestingly, there was a 9 percent decrease from 2018 to 2019). In comparison the number of patent applications at the

USPTO increased by only 35% (from 456,000 to 621,000) over the same period. Hence, while in 2009 U.S. patent applications outnumbers Chinese applications by almost two-to-one, by 2019, the ratio had completely reversed. Most of the Chinese patenting increase can be attributed to applications filed by domestic applicants. Out of the 1.4 million CNIPA applications in 2019, domestic sources filed almost 90 percent (compared to 48 percent of USPTO applications)." See Patrick Thomas & Dewey Murdick, *Patents and Artificial Intelligence: A Primer*, Center for Security and Emerging Technology at 10 (Sept. 2020), https://cset.georgetown.edu/wp-content/uploads/CSET-Patents-and-Artificial-Intelligence.pdf. In 2019, there were also almost two million utility model applications in China. Id at n. 17.

"China has met its strategic policy goal of increasing the quantity of its patent applications and issued patents, creating the narrative that it has "won" the innovation race."

Third, regardless of quality concerns,[14] China's prolific patent application filings may further hurt U.S. innovators by creating a vast reservoir of "prior art" (the term in patent law for the worldwide scientific and technical knowledge by which an invention is evaluated to determine if it is new). This dramatically increases the quantity of prior art that must be reviewed in examining a patent application. As a result, the patent examination process at the USPTO will become increasingly difficult, if not onerous. At the same time, U.S. inventors may find it more difficult to obtain patents because they must show that their inventions are not disclosed in the prior art publications anywhere in the world, including in the Chinese-language patent applications filed in China and internationally.[15] As Chinese patents come to dominate prior art searches by patent offices throughout the world, the current dominance of U.S. patents in worldwide prior art searches will erode.[16]

Fourth, and consistent with China's extensive patent application filings, China's companies have been identifying too many patents as "standard-essential" in standards development organizations, alleging that these patents must be practiced to comply with a technical standard.[17] Although standard development organizations require patent owners to self-identify patents that may be deemed essential in future standards, these organizations leave final essentiality determinations to private companies negotiating licenses or, if there is a dispute, to courts.[18] This practice of "overdeclaring" standard-essential patents (SEPs) furthers China's global narrative that it has "won" the race to such standardized

technologies as 5G, prompting other countries to adopt China's technologies in their own communications infrastructures.[19] A worrisome result may be that U.S. companies must pay billions in royalties to China's companies or face claims and resulting litigation that they willfully infringed on Chinese company patent rights.[20]

Fifth, the lack of explicit legal protections for data or express policies on data ownership may hinder innovation and collaboration, particularly as technologies evolve.[21] The absence of data protection regimes may disincentivize parties from making necessary investments to develop data sets that are critical for machine learning (ML) and AI systems.[22] Additionally, the absence of data governance policies (such as contracting best practices) for IP-type protections or ownership rules could undermine the willingness of companies to enter into the public-private partnerships that are crucial for creating cutting-edge technological innovations.[23] This could also create challenges for U.S. collaboration with allies and other partners in vital AI R&D where data rights or ownership claims come into question.[24]

Lastly, as further evidence that China views IP as essential in its domestic economic development, China continues to pervasively steal American IP-protected technological advances through varied means like cyber hacking of businesses and research institutes, technological espionage, blackmail, and illicit technology transfer.[25]

"China continues to pervasively steal American IP-protected technological advances through varied means like cyber hacking of businesses and research institutes, technological espionage, blackmail, and illicit technology transfer."

The IP Policy Void.

The U.S. Government needs to address these vulnerabilities resulting from the lack of comprehensive IP policies. Currently, the U.S. Government does not efficiently utilize IP policy as a tool to support national strategies for national security, economic interests, and technology competitiveness in AI and emerging technologies. The majority of the United States Government's coordinated IP policy efforts are focused on IP enforcement and preventing IP theft.[26] The U.S., however, lacks an agency or interagency entity that is empowered to both develop and execute national IP policies that support and integrate with national strategies. As a result, the United States lacks cohesive, legislatively mandated AI and emerging-technology IP policies that are integrated into national strategy frameworks to address, for example, global competition from countries like China.

America's IP laws and institutions must be considered as critical components for safeguarding U.S. national security interests, including advancing economic prosperity and technology competitiveness. The United States must, at a minimum, articulate and develop national IP reforms and policies with the goal of incentivizing, expanding, and protecting AI and emerging technologies, at home and abroad. Such policies should be developed and proposed via the Executive Branch with a process that integrates the disparate departments and agencies that serve important roles in promoting U.S. innovation. The Executive Branch should:

"America's IP laws and institutions must be considered as critical components for safeguarding U.S. national security interests, including advancing economic prosperity and technology competitiveness."

Recommendation

Develop and implement national IP policies to incentivize, expand, and protect AI and emerging technologies. The President should issue an executive order to recognize IP as a national priority and require the development of a comprehensive plan to reform and create IP policies and regimes that further national security, economic interests, and technology competitiveness strategies. The Commission recommends that the executive order direct the Vice President, as chair of the Technology Competitiveness Council (TCC), or otherwise as chair of an interagency task force, to oversee this effort. The executive order should direct the Secretary of Commerce—in coordination with the Under Secretary of Commerce for Intellectual Property and the Director of the USPTO[27]—to develop proposals to reform and establish new IP policies and regimes, as needed, to incentivize, expand, and protect AI and emerging technologies. The plan should include proposals for executive and legislative actions for IP policy changes to achieve these objectives and should be accompanied by an assessment of a non-exhaustive list of "IP considerations."[28] The Executive Order should direct the Vice President to assess which IP policies, regimes, and reform proposals from the Secretary of Commerce should be integrated into national security, economic, and technology competitiveness strategies and empower the Secretary of Commerce to facilitate implementation of such proposals.

National Intellectual Property Considerations.

Chapter 12 - Endnotes

[1] Advances in emerging technologies require significant investments. These investments are partly public, but advances also require extensive private investments.

[2] Technologies critical to national security interests include AI and biotechnology. NSCAI proposes an initial list of emerging technologies key to U.S. national competitiveness in Chapter 16 of this report.

[3] CSET translation of *National 13th Five-Year Plan for the Development of Strategic Emerging Industries*, Central People's Government of the People's Republic of China at 59 (Nov. 29, 2016) (translation by CSET on Dec. 9, 2019), https://cset.georgetown.edu/research/national-13th-five-year-plan-for-the-development-of-strategic-emerging-industries/. China continues to make extensive reforms to its IP regimes in furtherance of its innovation and industrial competitiveness goals. See Mark Cohen, *IPO's Comments on Recent Patent Legislation: Untangling a Complex We*b, China IPR blog (Dec. 15, 2020), https://chinaipr.com/2020/12/15/ipos-comments-on-recent-patent-legislation-untangling-a-complex-web/.

[4] China's actions include ensuring that AI and associated technologies are eligible for patent protection, increasing damages awards for patent infringement, continuing to issue preliminary injunctions for infringement of valid patents, and creating specialized IP courts with more efficient resolution of IP cases. See Kevin Madigan & Adam Mossoff, *Turning Gold into Lead: How Patent Eligibility Doctrine Is Undermining U.S. Leadership in Innovation*, George Mason Law Review at 943-946 (April 13, 2017), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2943431 [hereinafter Turning Gold Into Lead]; Ryan Davis, *4 Things to Know About China's Revised Patent Law*, Law 360 (Nov. 5, 2020), https://www.law360.com/articles/1326419/; Liaoteng Wang et. al., *A Comparative Look at Patent Subject Matter Eligibility Standards: China Versus the United States*, IP Watchdog (June 12, 2020), https://www.ipwatchdog.com/2020/06/12/comparative-look-patent-subject-matter-eligibility-standards-china-versus-united-states/id=122339/; Erick Robinson, *Everything You Need to Know about China's New Preliminary Injunction Rules*, IAM (Dec. 21, 2018), https://www.iam-media.com/designs/everything-you-need-know-about-chinas-new-preliminary-injunction-rules; Justice Tao Kaiyuan, *China's Commitment to Strengthening IP Judicial Protection and Creating a Bright Future for IP Rights*, World Intellectual Property Organization, WIPO Magazine (June 2019), https://www.wipo.int/wipo_magazine/en/2019/03/article_0004.html.

[5] See Turning Gold Into Lead, at 955.

[6] See Turning Gold Into Lead. In January 2019, the United States Patent & Trademark Office (USPTO) published initial patent eligibility guidance that applies during examination of patent applications at the USPTO, which arguably decreased uncertainty as to patent eligibility determinations during the patent application examination and granting process. However, the United States Court of Appeals for the Federal Circuit, the appellate court with jurisdiction of appeals from patent cases, held that it is not bound by the Guidance. See *Cleveland Clinic Found. v. True Health Diagnostics LLC*, 760 F. App'x at 1013, 1020 (Fed. Cir. 2019) (non-precedential); *In re Rudy*, 956 F.3d 1379, 1383 (Fed. Cir. 2020) (precedential) (citing *Cleveland Clinic Found.*, 760 F. App'x at 1021).

[7] *Athena Diagnostics v. Mayo Collaborative Services*, 915 F.3d 743 (Fed. Cir. 2019), rehearing en banc denied 927 F.3d 1333 (Fed. Cir. 2019) (method of diagnosing certain, previously undiagnosable, patients suffering from the neurological disorder myasthenia gravis using MuSK autoantibodies); *The Cleveland Clinic Found. v. True Health Diagnostics LLC*, 760 F. App'x 1013 (Fed. Cir. 2019) (method of assessing the risk a patient has cardiovascular disease by analyzing the level of a certain enzyme in a patient's blood); *Roche Molecular Systems, Inc. v. Cepheid*, 905 F.3d 1363 (Fed. Cir. 2018) (DNA primers used in a method to detect the pathogenic bacterium Mycobacterium tuberculosis); *Ariosa Diagnostics, Inc. v. Sequenom, Inc.*, 788 F.3d 1371 (Fed. Cir. 2015), *cert. denied,* 136 S. Ct. 2511 (2016) (method of diagnosing fetal characteristics based on paternally inherited DNA found in a mother's bloodstream without creating a major health risk for the fetus); *PUREPREDICTIVE, Inc. v. H20.AI, Inc.*, No. 17-cv-03049-WHO, 2017 WL 3721480 (N.D. Cal. Aug. 29, 2017) (predictive analytics); *Power Analytics Corp. v. Operation Tech., Inc.*, No. 16-cv-01955 JAK (FFMx), 2017 WL 5468179 (C.D. Cal. July 13, 2017) ("computer simulation techniques with real-time system monitoring and prediction of electrical system performance").

Chapter 12 - Endnotes

[8] See *Crash Course on Patents: What Is a Patent and Why Is It Useful*, Ius mentis (last accessed Dec. 30, 2020), https://www.iusmentis.com/patents/crashcourse/whatis/ (because patents openly publish details of the invention, other inventors can license this invention or think of enhancements or design around the disclosure); Steven Hoffman & Calla Simeone, *Trade Secret Protection & the COVID-19 Cure: Observations on Federal Policy-Making & Potential Impact on Biomedical Advances*, JDSupra (Sept. 15, 2020), https://www.jdsupra.com/legalnews/trade-secret-protection-the-covid-19-37383/ (discussing implications of uncertainty in patent eligibility on use of trade secrets for biomedical advances).

[9] Surveys and industry reports demonstrate that investment has already shifted away from patent-intensive industries. See Mark F. Schultz, *The Importance of an Effective and Reliable Patent System to Investment in Critical Technologies*, Alliance for U.S. Startups and Investors for Jobs at 24-37 (July 2020), https://static1.squarespace.com/static/5746149f86db43995675b6bb/t/5f2829980ddf0c536e7132a4/1596467617939/USIJ+Full+Report_Final_2020.pdf.

[10] Patrick Thomas & Dewey Murdick, *Patents and Artificial Intelligence: A Primer,* Center for Security and Emerging Technology at 10 (Sept. 2020), https://cset.georgetown.edu/wp-content/uploads/CSET-Patents-and-Artificial-Intelligence.pdf [hereinafter CSET, A Primer]; *U.S. Patent Statistics Chart Calendar Years 1963-2019*, USPTO (April 2020), https://www.uspto.gov/web/offices/ac/ido/oeip/taf/us_stat.htm.

[11] See CSET, A Primer at 11; Aaron Wininger, *China Surpasses U.S. to Become Top Filer of PCT International Patent Applications in 2019*, National Law Review (April 7, 2020), https://www.natlawreview.com/article/china-surpasses-us-to-become-top-filer-pct-international-patent-applications-2019. China is on pace to continue being the top PCT filer in 2020. See Aaron Wininger, *China 2020 H1 Patent Data Indicates China Likely to Remain Top International Filer in 2020*, National Law Review (July 11, 2020), https://www.natlawreview.com/article/china-2020-h1-patent-data-indicates-china-likely-to-remain-top-international-filer.

[12] *AI Innovators*, RS (last accessed Dec. 30, 2020), https://uk.rs-online.com/web/generalDisplay.html?id=did-you-know/ai-innovators; George Leopold, *China Dominates AI Patent Filings*, Enterprise AI (Aug. 31, 2020), https://www.enterpriseai.news/2020/08/31/china-dominates-ai-patent-filings/; CSET, A Primer.

[13] CSET, A Primer at 9, 12, n. 23.

[14] *Trademarks and Patents in China: The Impact of Non-Market Factors on Filing Trends and IP Systems*, USPTO at 1 (Jan. 2021), https://www.uspto.gov/sites/default/files/documents/USPTO-TrademarkPatentsInChina.pdf; Jonathan Putnam, et al., *Innovative Output in China*, SSRN at 32 (Aug. 2020) (pending revision), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3760816.

[15] Jeanne Suchodolski, et al., *Innovation Warfare*, North Carolina Journal of Law & Technology at 201 (Dec. 7, 2020), https://ncjolt.org/articles/volume-22/volume-22-issue-2/innovation-warfare/ [hereinafter Innovation Warfare].

[16] Rob Sterne, *How China Will Fundamentally Change the Global IP System*, IP Watchdog (July 24, 2019), https://www.ipwatchdog.com/2019/07/24/china-changing-global-ip-system/id=111613/.

[17] Over-declaration is already present in 5G. See Matthew Noble, et al., *Determining Which Companies Are Leading the 5G Race*, IAM (July/August 2019), https://www.twobirds.com/~/media/pdfs/news/articles/2019/determining-which-companies-are-leading-the-5g-race.pdf?la=en&hash=8ABA5A7173EEE8FFA612E070C0EA4B4F53CC50DE; *Meeting the China Challenge: A New American Strategy for Technology Competition*, Working Group on Science and Technology in U.S.-China Relations at 27, 29 (Nov. 16, 2020), https://china.ucsd.edu/_files/meeting-the-china-challenge_2020_report.pdf [hereinafter Meeting the China Challenge].

[18] *IEEE SA Standards Board Bylaws*, IEEE Standards Association (last accessed Jan. 15, 2020), https://standards.ieee.org/about/policies/bylaws/sect6-7.html#loa.

[19] *5G Technological Leadership*, Hudson Institute (Dec. 5, 2020), https://www.hudson.org/research/16547-5-g-technological-leadership; *Innovation Warfare*, at 201, n.130 (China's firms recognize the strategic importance of standard-setting activities and that participation in those forums provides the legal means to both access and influence developing technologies).

[20] Because standard-essential patents (SEPs) may reach into the hundreds of thousands for technologies, licensing fees carry significant economic repercussions. See *5G Technological Leadership*, Hudson Institute at 3 (Dec. 5, 2020), https://www.hudson.org/research/16547-5-g-technological-leadership ("[P]atent counting might have negative consequences on firms working in the US innovation economy … if judges or regulators rely on simple counts of total patents as a metric for determining the value of patent portfolios. The failure to account for differences in patent quality risks overcompensating some patent holders, namely those with less valuable technologies, but undercompensating those that have developed breakthrough innovation."); Andrei Iancu, Director of USPTO, Remarks at the Center for The Protection of Intellectual Property 2020 Fall Conference (Oct. 7, 2020), https://cpip.gmu.edu/2020/10/20/cpip-2020-fall-conference-day-one-recap/; Muzammil Hassan, et al., *Who Owns Core 5G Patents? A Detailed Analysis of 5G SEPs*, GreyB (2020), https://www.greyb.com/5g-patents/#The-State-of-Declared-5G-Patents; Cody M. Akins, *Overdeclaration of Standard-Essential Patents*, Texas Law Review (2020), https://texaslawreview.org/wp-content/uploads/2020/02/Akins.Printer.pdf.

[21] Mitchell Smith, *A Comparison of the Legal Protection of Databases in the United States and EU: Implications for Scientific Research*, SSRN (May 23, 2010), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1613451; Daniel J. Gervais, *Exploring the Interfaces Between Big Data and Intellectual Property Law*, Journal of Intellectual Property, Information Technology and Electronic Commerce Law (2019), https://scholarship.law.vanderbilt.edu/faculty-publications/1095.

[22] In the USPTO report surveying stakeholders for perspectives on IP policy for AI, "[c]ommenters were nearly equally divided between the view that new intellectual property rights were necessary to address AI inventions and the belief that the current U.S. IP framework was adequate to address AI inventions. Generally, however, commenters who did not see the need for new forms of IP rights suggested that developments in AI technology should be monitored to ensure needs were keeping pace with AI technology developments. The majority of opinions requesting new IP rights focused on the need to protect the data associated with AI, particularly ML." *Public Views on Artificial Intelligence and Intellectual Property Policy*, USPTO at 15 (Oct. 2020), https://www.uspto.gov/sites/default/files/documents/USPTO_AI-Report_2020-10-07.pdf.

[23] Thomas E. Ayers, *Changing How We Buy Weapons Will Benefit Industry, Government and Taxpayers*, Defense News (Nov. 20, 2019), https://www.defensenews.com/opinion/commentary/2019/11/20/changing-how-we-buy-weapons-will-benefit-industry-government-and-taxpayers/ (discussing the tension between Air Force and vendors over IP protection).

[24] See also the Chapter 15 Blueprint for Action.

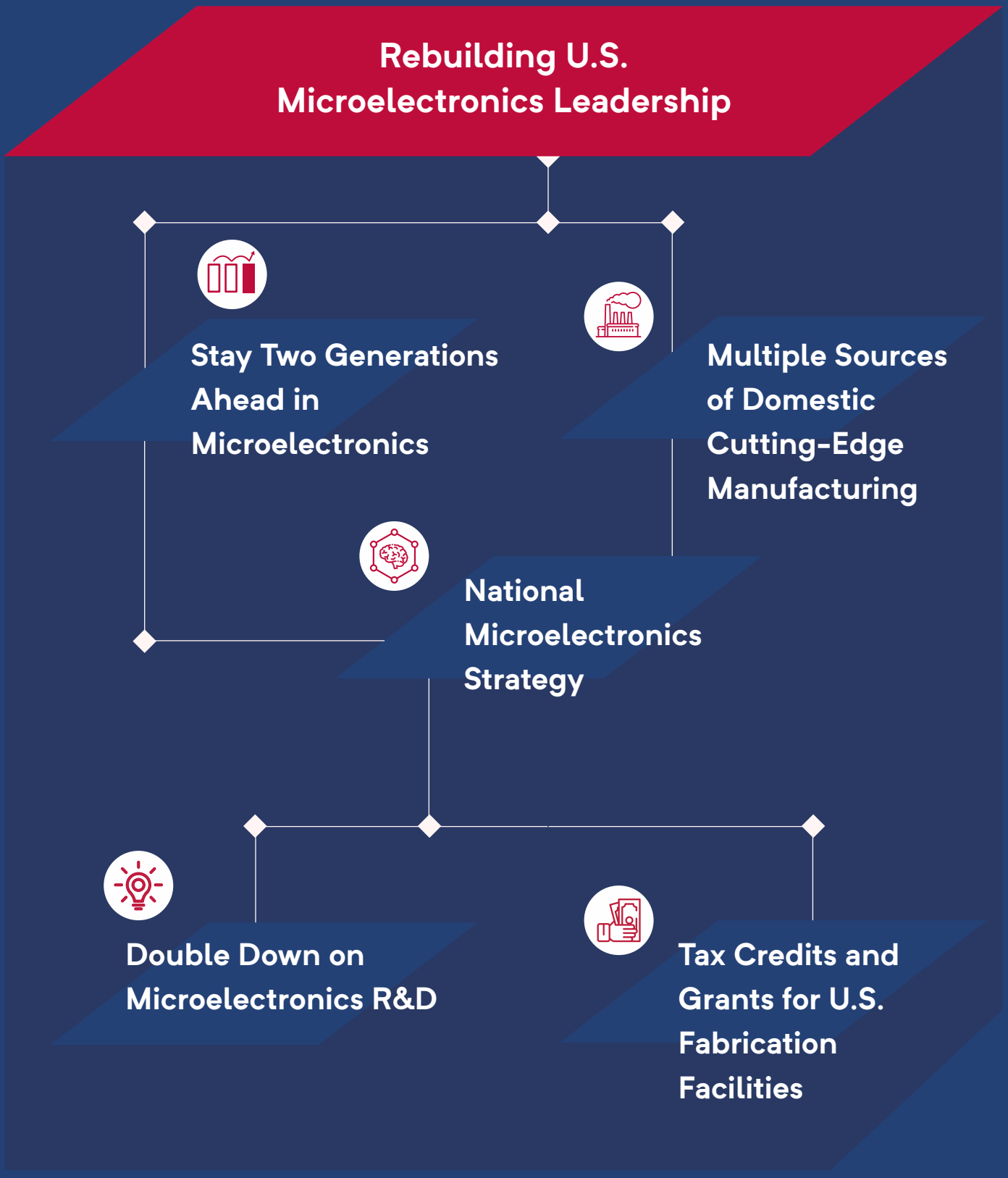
[25] Meeting the China Challenge, at 4, 16.

[26] *Annual Intellectual Property Report to Congress*, U.S. Intellectual Property Enforcement Coordinator (March 2020), https://trumpwhitehouse.archives.gov/wp-content/uploads/2020/04/IPEC-2019-Annual-Intellectual-Property-Report.pdf (providing an overview of IP responsibilities across the United States government).

[27] Other Executive Branch departments and agencies, and the U.S. Copyright Office, should resource and support the Secretary of Commerce in these efforts.

[28] A non-exhaustive list of IP considerations should include patent eligibility doctrine, countering China's narrative on "winning" AI innovation based on patent application filings, the impact of China's patent application filings on USPTO's examination process and U.S. inventors, impediments in IP contractual system to public-private partnerships and international collaboration, IP protections for data, combatting IP theft, AI inventorship, global IP alignment, democratizing innovation and IP ecosystems, and SEPs process.

Chapter 13: Microelectronics


Rebuilding U.S. Microelectronics Leadership
Stay Two Generations Ahead in Microelectronics
Multiple Sources of Domestic Cutting-Edge Manufacturing
National Microelectronics Strategy
Double Down on Microelectronics R&D
Tax Credits and Grants for U.S. Fabrication Facilities

U.S. leadership in microelectronics is critical to overall U.S. leadership in artificial intelligence (AI). Several assessments underpin this argument:

- Hardware is a foundational element of the AI stack alongside data, algorithms, and talent.[1]
- Exponential increases in computational power have driven the last decade of progress in machine learning (ML).[2]
- After decades leading the microelectronics industry, the United States will soon source roughly 90% of all high-volume, leading-edge integrated-circuit production from countries in East Asia.[3] This means the United States is almost entirely reliant on foreign sources for production of the cutting-edge semiconductors critical for defense systems and industry more broadly, leaving the U.S. supply chain vulnerable to disruption by foreign government action or natural disaster.
- Specialized hardware, novel packaging techniques such as heterogeneous integration and 3D stacking, and new types of devices will drive future AI developments as traditional architectures of silicon-based chipsets encounter diminishing marginal performance improvements.[4]
- Demand for trusted microelectronics will only grow as the military and Intelligence Community (IC) continue to incorporate AI into mission-critical systems.[5]

“... the United States is almost entirely reliant on foreign sources for production of the cutting-edge semiconductors critical for defense systems and industry more broadly, leaving the U.S. supply chain vulnerable to disruption by foreign government action or natural disaster.”

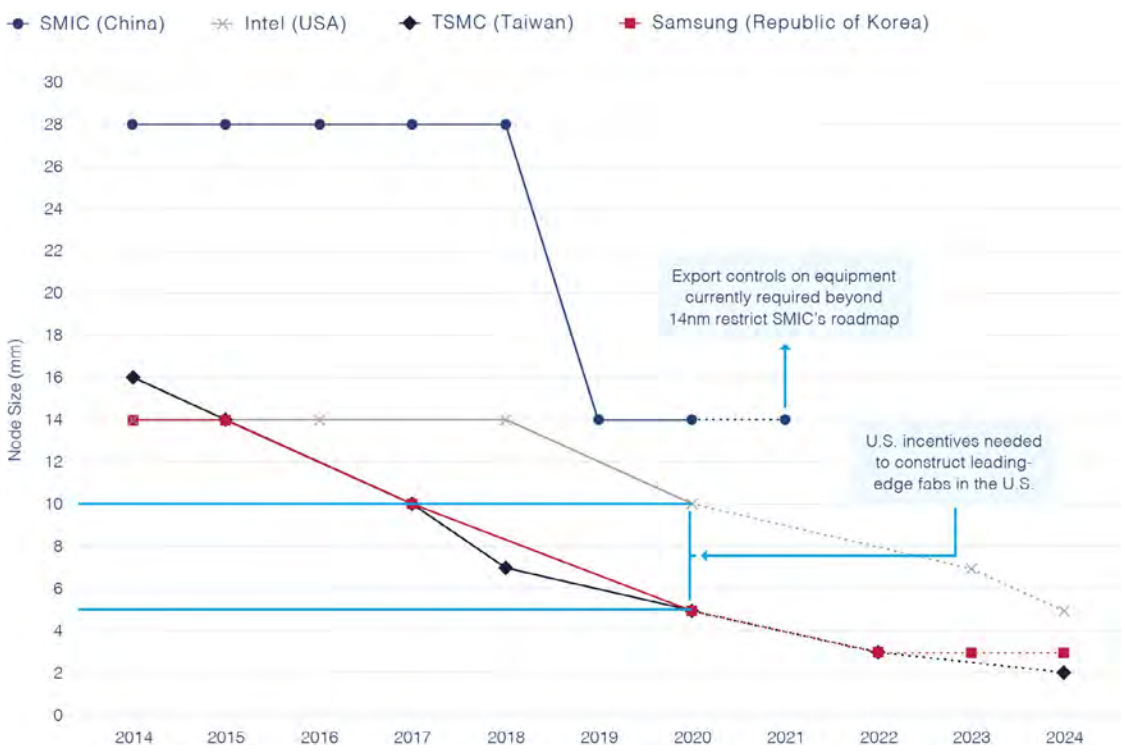
U.S. leadership in semiconductors has long been taken for granted based on America's advantage as a pioneer of the microelectronics industry. Gradually, however, the United States has been losing its edge. Although American universities and firms remain global leaders in the key areas of semiconductor R&D and chip design, the semiconductor industry is now highly globalized and competitive. Taiwan Semiconductor Manufacturing Corporation (TSMC) leads the world in semiconductor contract manufacturing, and Samsung in South Korea is also producing state-of-the-art logic chips.[6] TSMC also leads in the production of ARM-based chips, which is becoming the predominant chip architecture for mobile devices, servers, and other key applications of emerging technologies.[7] In a bid to catch up and achieve chip self-sufficiency, China is pursuing unprecedented state-funded efforts to forge a world-leading semiconductor industry by 2030. Although China is behind firms headquartered in Taiwan, South Korea, and the U.S. in terms of chip manufacturing, it is advancing quickly.[8] Meanwhile, Intel, the leading U.S. manufacturer, remains competitive in chip design but has faced manufacturing setbacks for leading-edge chips and may fall further behind its rivals in Taiwan and South Korea. Current projections put the firm two generations or more behind the cutting-edge node by 2022.[9] These and other concerning trends indicate that America's leadership in microelectronics is eroding, especially in manufacturing, assembly, testing, and packaging.[10]

The dependency of the United States on semiconductor imports, particularly from Taiwan, creates a strategic vulnerability for both its economy and military to adverse foreign government action, natural disaster, and other events that can disrupt the supply chains for electronics. Despite tremendous expertise in microelectronics research, development, and innovation across the country, the United States is constrained by a lack of domestically-located semiconductor fabrication facilities, especially for state-of-the-art semiconductors. If current trends continue, the United States will soon be unable to catch up in fabrication, and could eventually also be outpaced in microelectronics design. If a potential adversary bests the United States in semiconductors over the long term or suddenly cuts off U.S. access to cutting-edge chips entirely, it could gain the upper hand in every domain of warfare. Focusing the efforts of the U.S. Government, industry, and academia to develop domestic microelectronics fabrication facilities will reduce dependence on imports, preserve leadership in technological innovation, support job creation, improve national security and balance of trade, and enhance the technological superiority and readiness of the military, which is an important consumer of advanced microelectronics.

"Despite tremendous expertise in microelectronics research, development, and innovation across the country, the United States is limited by a lack of domestically-located semiconductor fabrication facilities ..."

State-of-the-Art Semiconductor Manufacturing by Firm: 2014-2024.

State-of-the-Art Semiconductor Manufacturing by Firm: 2014-2024



Node size for 2021-2024 are projections and reflect firm roadmaps

Node size reflects estimated first year of mass production

No roadmap displayed beyond 2021 for SMIC due to export control restrictions on materials currently required for production beyond 14 nm

To regain U.S. leadership in microelectronics, the Executive Branch should finalize and implement a national microelectronics leadership strategy. Additionally, Congress should create a 40% refundable tax credit for domestic fabrication investments by firms from the United States and its allies and appropriate an additional $12 billion over the next five years for microelectronics research, development, and infrastructure. Together these efforts will enable the U.S. government, private sector, and academia to rise to the challenge of rebuilding U.S. semiconductor superiority.

Objective: Stay two generations ahead of China in state-of-the-art microelectronics and maintain multiple sources of cutting-edge microelectronics fabrication in the United States.

The United States should focus the attention and resources necessary for long-term competition in microelectronics by adopting an overarching national objective: to stay two generations ahead of potential adversaries in state-of-the-art microelectronics while also maintaining multiple sources of cutting-edge microelectronics fabrication inside the United States.[11] While the United States has historically led China by at least two generations in semiconductor design and fabrication, this has not been an explicit policy goal. And while China has not been able to surpass the United States, other nations such as Taiwan and South Korea now clearly lead the U.S. in state-of-the-art semiconductor manufacturing. This leaves the U.S. reliant on foreign sources for critical inputs to defense systems and U.S. industry more broadly. Yet the United States retains a strong position in segments of the global value chain for semiconductors, such as design, electronic design automation tools, and semiconductor manufacturing equipment (SME).[12] Therefore, an objective to rebuild microelectronics leadership should be stated plainly to concentrate national support across government, industry, and academia on regaining leadership in sectors such as semiconductor fabrication where the United States has fallen behind and also to track progress over time against a clear yardstick. To achieve this objective, the Commission recommends focusing action along three fronts:

- Implementing a national microelectronics strategy;
- Revitalizing domestic microelectronics fabrication by incentivizing multiple cutting-edge domestic fabrication facilities; and
- Ramping up microelectronics research.

In addition to these efforts to promote U.S. microelectronics leadership, the United States and its allies should utilize targeted export controls on high-end semiconductor manufacturing equipment, described in Chapter 14 of this report, to protect existing technical advantages and slow the advancement of China's semiconductor industry.

U.S. leadership in microelectronics is essential to overall U.S. leadership in AI.

Recommendation

Implement the National Microelectronics Strategy. The United States lacks a national microelectronics strategy to coordinate semiconductor policy, funding, and incentives within the Executive Branch and externally with industry and academia. A truly national strategy would build on this Commission's work as well as previous studies conducted by the United States government or on its behalf. It would also integrate the disparate approaches of the Departments of State, Defense, Energy, Commerce, and Treasury, and other relevant agencies, to promote domestic R&D and semiconductor manufacturing expertise while preventing the illicit transfer of technology to competitors. Finally, it would be updated on a consistent basis to foster a coordinated approach and adapt to shifting challenges to microelectronics innovation, competitiveness, and supply chain integrity.

In line with the Commission's recommendations, the Fiscal Year 2021 National Defense Authorization Act (NDAA) creates a subcommittee of the National Science and Technology Council (NSTC), consisting of senior government officials, to develop a National Strategy on Microelectronics Research and oversee its implementation.[13] However, for this key effort to be successful, it should be prioritized by the White House by requiring the NSTC subcommittee to submit the National Microelectronics Strategy to the President within 270 days.

Recommendation

Revitalize domestic microelectronics fabrication. The Commission concludes that the United States is overly dependent upon globally diversified supply chains for microelectronics, including imports from potential adversaries. Furthermore, as a result of gaps in the U.S. industrial base, the risks are increasing that the United States could lose access to trusted, assured, and state-of-the-art semiconductors for national security use cases. Despite these concerns, the Commission has been encouraged by a number of developments over the past year to revitalize the domestic fabrication of state-of-the-art microelectronics.

> **"... the United States could lose access to trusted, assured, and state-of-the-art semiconductors for national security use cases."**

Examples include TSMC's decision to develop an advanced facility in the United States and Intel's publicly stated interest in working with the United States government to develop a commercial U.S. foundry.[14] However, these are only initial steps, and more must be done by the U.S. government to reach an end state where multiple firms are fabricating state-of-the-art chips domestically. Without several U.S.-based fabrication facilities, both U.S. industry and U.S. national security face risks from competitive pressures and supply chain shortages. The most significant recent development has been the inclusion of several semiconductor-related provisions from the "CHIPS for America Act" in the Fiscal Year 2021 National Defense Authorization Act (NDAA).[15] However, these programs require sufficient appropriations to succeed, and they did not receive appropriated funding in Fiscal Year 2021, which leaves congressional priorities unclear. Further congressional action to establish refundable investment tax credits and set the conditions for the domestic production of advanced microelectronics will be important to enable the United States to remain two generations ahead of China. Specifically, the U.S. government should:

- **Incentivize domestic leading-edge merchant fabrication through refundable investment tax credits.** Although introduced as part of the CHIPS for America Act, Congress has not yet passed legislation establishing a 40% refundable investment tax credit for semiconductor facilities and equipment.[16] Existing U.S. incentives reduce the cost of foundry construction attributable to capital expenses, operating expenses, and taxes by just 10% to 15%. A credit of this magnitude is needed to make the United States a competitive market for semiconductor manufacturing, as other leading semiconductor manufacturing nations such as South Korea, Taiwan, and Singapore offer 25% to 30% cost reduction, roughly double what the United States currently offers.[17] This gap in incentives is one driving factor behind the lack of an advanced logic merchant foundry in the United States. Closing the incentive gap and broadening it to include companies from allied countries will incentivize U.S. firms to construct facilities domestically while also attracting foreign firms such as TSMC and Samsung. Additionally, increasing demand in the United States for high-end SME will create new business opportunities for SME manufacturers from allied countries, particularly Japan and the Netherlands, which could increase their governments' willingness to align their export control policies with strict U.S. policies prohibiting the export of such equipment to China.[18]

"... other leading semiconductor manufacturing nations such as South Korea, Taiwan, and Singapore offer 25 to 30 percent cost reduction, roughly double what the United States currently offers."

Recommendation

Double-down on federally funded microelectronics research. Each succeeding generation of chips using traditional architectures of silicon-based transistors faces diminishing marginal gains to performance as they reach the limits imposed by the laws of physics. As a result, the relative advantage the United States has enjoyed by staying roughly two generations ahead of potential adversaries in the design phase of developing cutting-edge hardware could decrease over time as the gap between hardware generations narrows. Therefore, the United States must look to heterogeneous integration and other novel hardware improvements in the medium term to continue out-innovating competitors. Over the longer term, the United States must also continue its portfolio approach to future microelectronics pathways by investing in new materials and entirely new hardware approaches, such as quantum and neuromorphic computing. Broad-based investments and incentives will also be important to maintain leadership in other areas of U.S. strength related to semiconductor manufacturing, including electronic design automation tools and SME.

Four primary research arms of the United States government focused on both medium- and long-term microelectronics breakthroughs are the Department of Energy, Defense Advanced Research Projects Agency (DARPA), National Science Foundation (NSF), and the Department of Commerce, primarily through engagement with industry. Their suite of existing programs, such as DARPA's Electronics Resurgence Initiative, is targeting the right research areas but must expand by an order of magnitude to achieve the necessary breakthroughs and maintain U.S. competitiveness. Additional funding should support not only research projects, but also the capital-intensive underlying infrastructure for microelectronics development, including the National Semiconductor Technology Center and advanced packaging prototyping activities authorized in the Fiscal Year 2021 NDAA. In particular, advances in packaging will be critical to future improvements in semiconductor

capabilities as firms reach physical limits for two-dimensional transistor density.[19] The government should:

- **Double down on federal research funding to lead the next generation of microelectronics.** The Commission recommends substantially increasing the United States government's full range of research efforts focused on microelectronics. Congress should appropriate an additional $1.1 billion for semiconductor research and $1 billion for the Advanced Packaging National Manufacturing Program in Fiscal Year 2022. Building on these investments, these funding levels should continue for five years, for a total investment of roughly $12 billion. These amounts are consistent with the funding levels introduced, but not yet appropriated, in the CHIPS for America Act[20] and the American Foundries Act of 2020.[21] In line with the existing focus areas of these programs and the Commission's prior recommendations, the funding should be applied to developing infrastructure and pursuing breakthroughs in promising areas such as next-generation tools beyond extreme ultraviolet lithography, 3D chip stacking, photonics, carbon nanotubes, gallium nitride transistors, domain-specific hardware architectures, electronic design automation, and cryogenic computing.

"... advances in packaging will be critical to future improvements in semiconductor capabilities as firms reach physical limits for two-dimensional transistor density."

Chapter 13 - Endnotes

[1] Dave Martinez, et al., *Artificial Intelligence: Short History, Present Developments, and Future Outlook*, MIT at 27, n. 10 (Jan. 2019), https://www.ll.mit.edu/sites/default/files/publication/doc/2019-09/Artificial%20Intelligence%20Short%20History%2C%20Present%20Developments%2C%20and%20Future%20Outlook%20-%20Final%20Report%20-%20Martinez.pdf (citing Andrew Moore, et al., *The AI Stack: A Blueprint for Developing and Deploying Artificial Intelligence*, International Society for Optics and Photonics, Ground/Air Multisensor Interoperability, Integration, and Networking for Persistent ISR IX [2018]).

[2] Recent machine learning (ML) breakthroughs have relied heavily on computing power, and the amount of compute used in the largest AI training runs has been increasing exponentially since 2012. Girish Sastry, et al., *Addendum: Compute Used in Older Headline Results*, OpenAI (Nov. 7, 2019), https://openai.com/blog/ai-and-compute/#addendum.

[3] Michaela Platzer, et al., *Semiconductors: U.S. Industry, Global Competition, and Federal Policy*, Congressional Research Service at 12 (Oct. 26, 2020), https://crsreports.congress.gov/product/pdf/R/R46581.

[4] Sara Hooker, *The Hardware Lottery*, arXiv (Sept. 21, 2020), https://arxiv.org/pdf/2009.06489.pdf.

[5] Gaurav Batra, et al., *Artificial Intelligence Hardware: New Opportunities for Semiconductor Companies*, McKinsey & Co. (Jan. 2, 2019), https://www.mckinsey.com/industries/semiconductors/our-insights/artificial-intelligence-hardware-new-opportunities-for-semiconductor-companies.

[6] Taiwan Semiconductor Manufacturing Corporation (TSMC) has already begun producing 5nm state-of-the-art logic chips and aims to produce 3nm chips by the end of 2021. Samsung is also producing 5nm chips. Intel does not anticipate producing 7nm chips in-house until at least 2022 and may outsource manufacturing to TSMC. Firms in China are producing 12 nm chips. Richard Waters, *Intel Looks to New Chief's Technical Skills to Plot Rebound*, Financial Times (Jan. 14, 2021), https://www.ft.com/content/51f63b07-aeb8-4961-9ce9-c1f7a4e326f0; Mark Lapedus, *China Speeds Up Advanced Chip Development*, Semiconductor Engineering (June 22, 2020), https://semiengineering.com/china-speeds-up-advanced-chip-development/; *5nm Technology*, TSMC (last accessed Jan. 16, 2021), https://www.tsmc.com/english/dedicatedFoundry/technology/logic/l_5nm; Debby Wu, *TSMC's $28 Billion Spending Blitz Ignites a Global Chip Rally*, Bloomberg (Jan. 14, 2021), https://www.bloomberg.com/news/articles/2021-01-14/tsmc-profit-beats-expectations-as-chipmaker-widens-tech-lead; Anton Shilov, *Samsung Foundry Update: 5nm SoCs in Production, HPC Shipments to Expand in Q4*, Tom's Hardware (Nov. 1, 2020), https://www.tomshardware.com/news/samsung-foundry-update-5nm-socs-in-production-hpc-shipments-to-expand-in-q4.

[7] *ARM and TSMC Announce Multi-Year Agreement to Collaborate on 7nm FinFET Process Technology for High-Performance Compute,* Design & Reuse (March 15, 2016), https://www.design-reuse.com/news/39433/arm-tsmc-7nm-finfet.html.

[8] Michaela D. Platzer, et al., *Semiconductors: U.S. Industry, Global Competition, and Federal Policy*, Congressional Research Service at 2, 25, 27 (Oct. 26, 2020), https://crsreports.congress.gov/product/pdf/R/R46581.

[9] Ian King, *Intel 'Stunning Failure' Heralds End of Era for U.S. Chip Sector*, Bloomberg (July 24, 2020), https://www.bloomberg.com/news/articles/2020-07-25/intel-stunning-failure-heralds-end-of-era-for-u-s-chip-sector.

[10] Michaela D. Platzer, et al., *Semiconductors: U.S. Industry, Global Competition, and Federal Policy*, Congressional Research Service (Oct. 26, 2020), https://crsreports.congress.gov/product/pdf/R/R46581.

[11] The Commission's previous reports offered a range of initial recommendations to expand access to trusted semiconductors, increase microelectronics R&D funding, control the export of high-end semiconductor manufacturing equipment to adversaries, and reshore leading-edge fabrication facilities.

[12] John VerWey, *The Health and Competitiveness of the U.S. Semiconductor Manufacturing Equipment Industry*, U.S. International Trade Commission: Office of Industries Working Paper (July 1, 2019), http://dx.doi.org/10.2139/ssrn.3413951.

[13] See Pub. L. 116-283, sec. 9906, William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, 134 Stat. 3388 (2021).

[14] Stephen Nellis, *Phoenix Okays Development Deal with TSMC for $12 Billion Chip Factory*, Reuters (Nov. 18, 2020), https://www.reuters.com/article/us-tsmc-arizona/phoenix-okays-development-deal-with-tsmc-for-12-billion-chip-factory-idUSKBN27Y30E; Asa Fitch, et al., *Trump and Chip Makers Including Intel Seek Semiconductor Self-Sufficiency*, Wall Street Journal (May 11, 2020), https://www.wsj.com/articles/trump-and-chip-makers-including-intel-seek-semiconductor-self-sufficiency-11589103002.

[15] See Pub. L. 116-283, William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, 134 Stat. 3388 (2021). These provisions authorize several programs the Commission has previously identified as essential to U.S. microelectronics leadership. In particular, the provisions would require drafting a National Microelectronics Leadership Strategy, establishing a National Semiconductor Technology Center, and creating an incubator for semiconductor startup firms and an Advanced Packaging National Manufacturing Institute, all of which align with previous recommendations from the Commission.

[16] This incentive would reduce a semiconductor firm's tax bill by 40% on semiconductor manufacturing equipment and facilities through 2024, followed by reduced tax credit rates of 30% and 20% respectively, through 2025 and 2026

[17] Antonio Varas, et al., *Government Incentives and US Competitiveness in Semiconductor Manufacturing*, BCG and SIA (Sept. 2020), https://web-assets.bcg.com/27/cf/9fa28eeb43649ef8674fe764726d/bcg-government-incentives-and-us-competitiveness-in-semiconductor-manufacturing-sep-2020.pdf.

[18] See Chapter 14 of this report for additional details on export controls on SME.

[19] *Heterogeneous Integration Roadmap: Chapter 1: HIR Overview and Executive Summary*, IEEE Electronics Packaging Society (Oct. 2019), https://eps.ieee.org/images/files/HIR_2019/HIR1_ch01_overview.pdf.

[20] See S. 3933 and H.R. 7178, Creating Helpful Incentives to Produce Semiconductors (CHIPS) for America Act, 116th Congress (2020).

[21] See S. 4130, American Foundries Act of 2020, 116th Congress (2020).