STEM immigration is critical to American national security

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Overview

Attracting and securing highly-skilled foreign-born talent is a key issue for U.S. competitiveness and national security. The House of Representatives recently passed the America COMPETES Act, which included immigration provisions in Section 80303 that exempt advanced STEM degree holders from green card caps. If Section 80303 makes it into the final bill, it will be easier for the U.S. to onshore and develop industries that are critical to achieving American national security objectives.

STEM immigration reform should not be an afterthought in a competitiveness bill, it should be central to our strategy for retaining American technological leadership.

Key takeaways:

China is catching up to the United States in scientific research and STEM talent.

- China has surpassed the United States in the number of advanced STEM degrees its students earn annually.
- For every percentage point that China increases the STEM share of its workforce, the United States would need to increase its own STEM share by four times as much in order to keep up, due to China's much larger population.
- The U.S. will need to complement domestic workforce education with reforms to expand high-skilled immigration.

A major bottleneck in growing the defense industrial base is overly restrictive immigration rules for high-skilled immigrants.

- Defense-related industries disproportionately rely on advanced STEM talent.
- The majority of workers in key emerging technologies like semiconductor fabrication, artificial intelligence, and quantum computing need advanced STEM degrees.

- 82% of companies in the defense industrial base report that it is difficult to find qualified STEM workers.
- 50% of the advanced degree holders working in the defense industrial base are foreign-born.
- STEM PhDs are central to research and development, but must be supplemented with STEM master's graduates to bring cutting-edge ideas into practical use in industry and military applications. Key defense-related industries like semiconductors, shipbuilding, and aerospace manufacturing employ multiple times as many STEM master's graduates as STEM PhDs.

Meeting the China challenge

The United States can no longer take it for granted that it will be the world's leader in STEM fields. While the United States is still ahead in cutting edge research, China has already caught up on numerous important metrics. If the United States is going to retain its international leadership, it will need to include immigration in its competitiveness strategy. Exempting top talent from existing restrictions will help retain American economic and technological leadership.

Chinese leaders have pursued what they term a "talent first" innovation strategy.[1] And their strategy is paying dividends. For the past 15 years, China has consistently graduated more students with advanced STEM degrees than the United States.[2] By one important metric of success in scientific research — the top 1 percent of the world's most cited research — Chinese science caught up to U.S. science as of 2019.[3] What's more, China has an easier time staying ahead because of its larger population, not to mention the fact that it has more low-hanging fruit left to pick in education because it is starting from lower initial levels. For every percentage point China increases the STEM share of its workforce, the United States would need to increase its own STEM share by four times as much if it wants to keep up. Upskilling domestic workers is an essential part of the U.S. response, but this kind of math means upskilling will need to be complemented by recruiting and retaining more high-skilled talent from around the world as well.

Meanwhile, Chinese leaders see the United States's current immigration system as an opportunity to poach talent and have expressed fears that the United States might expand its

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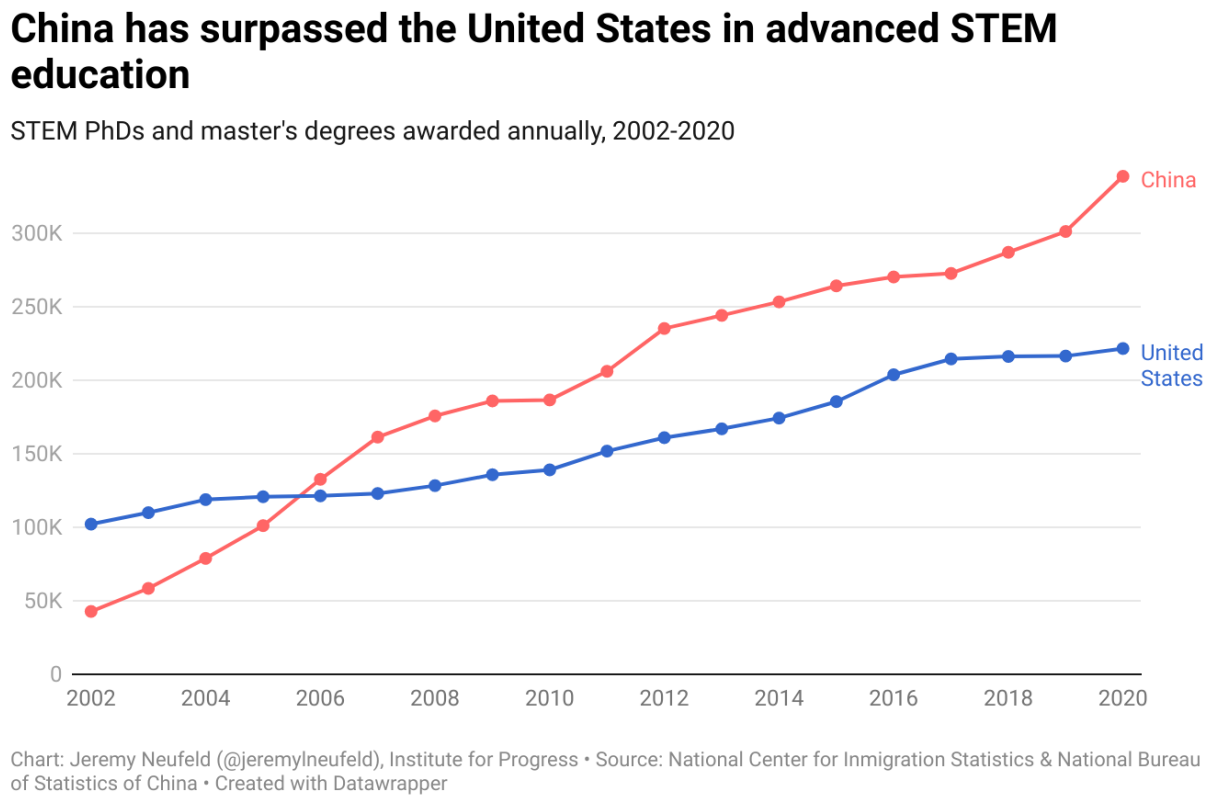
[1] Remco Zwetsloot, "China's Approach to Tech Talent Competition: Policies, Results, and the Developing Global Response."

[2] Author's analysis (see chart below). U.S. data came from the National Center for Education Statistics, "Digest of Education Statistics." Chinese data came from the National Bureau of Statistics of China, "China Statistical Yearbook." In the U.S. data, I treat the following fields as STEM fields: agriculture and natural resources, biological and biomedical sciences, computer and information sciences, engineering, engineering technologies, mathematics and statistics, military technologies and applied sciences, physical sciences and science technologies, and psychology. In China, STEM fields are science, engineering, agriculture, and military science.

[3] Wagner et al., "A discussion of measuring the top-1% most-highly cited publications: quality and impact of Chinese papers."

high-skilled immigration pipelines.[4] As one CCP-aligned government newspaper noted, it "would pose a huge challenge for China" if the United States expanded its employment-based immigration program.[5]



The United States has instead been complacent about its advantage in recruiting international talent and thereby put its technological leadership in jeopardy. For instance, annual caps on green cards have made the EB-2 visa — the immigrant visa for professionals with advanced degrees — essentially unusable[6] by critical industries trying to attract talent from India, a crucial region for technical talent. The result is an exodus of Indian talent out of the United States to other countries, taking their ideas, skills, and ambitions with them.[7]

The United States has allowed swelling queues, wait times, and processing backlogs to slow high-skilled immigration to a crawl, while other countries capture an increasing share of international talent. Canada, for instance, has responded to the opportunity by expanding their high skilled immigration targets and recruiting talent that the United States is turning away.[8] In

[4] Remco Zwetsloot, "Winning the Tech Talent Competition: Without STEM Immigration Reforms, the United States Will Not Stay Ahead of China."
[5] Quoted in ibid.
[6] The Congressional Research Service estimates the wait time for an Indian EB-2 applicant in 2020 is 195 years and will grow to over 400 years by 2030. See William A. Kandel, "The Employment-Based Immigration Backlog."
[7] Stuart Anderson, "Analysis of U.S. and Canadian International Student Data."
[8] Stuart Anderson, "Analysis of U.S. and Canadian International Student Data."

2021, Canada became the most desirable location for global talent, beating the United States and Australia, which has also worked to close the gap with the United States.[9] Despite China's active efforts, it has not yet become a net-immigration country that can compete with the United States for international talent. However, rising incomes could give China the pull-factor it needs if the United States does not reform its high-skilled immigration pathways.

As the final report by the National Security Commission on Artificial Intelligence recently noted: "for the first time in our lifetime, the United States risks losing the competition for talent on the scientific frontiers… Nations that can successfully attract and retain highly skilled individuals gain strategic and economic advantages over competitors."[10]

Thankfully, there is a bipartisan consensus that recruiting international STEM talent will be key to facing national security challenges. The House GOP China Task Force Report authored by Representative McCaul (R-TX-10) concluded in 2020:

> The U.S. must compete in the global race for talent by working to attract and retain the best and brightest minds to contribute to the U.S. economy and drive U.S. productivity. The U.S. has long relied on attracting foreign talent to fill STEM jobs, where the demand is greater than the domestic supply of highly skilled workers. As of 2017, over 40 percent of the U.S. doctoral-level workforce was foreign-born. In computer sciences, mathematics, and engineering, nearly 60 percent of PhD holders in the U.S. workforce are foreign-born…The U.S. cannot afford to take for granted that it will remain the destination of choice for STEM students.[11]

The defense industrial base needs international STEM talent

The defense industrial base is critical for our national security and is heavily reliant on international STEM talent. It has long been the case that international talent has disproportionately driven American innovation — more than 30% of U.S. patents are produced by immigrants and 33% of American Nobel are won by immigrants.[12] But the need for STEM talent is especially pronounced in defense-related industries. Not only are STEM workers with advanced degrees disproportionately employed by the defense industrial base, but 50% of advanced STEM workers in the defense industrial base are foreign-born.[13]

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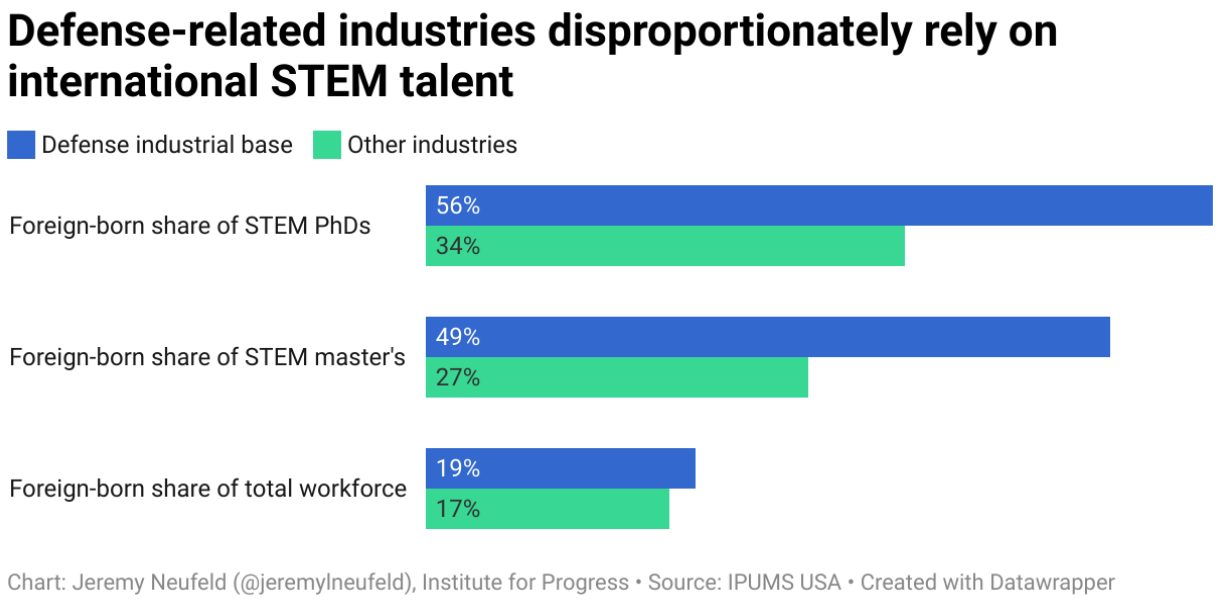
[9] Kovács-Ondrejkovic et al., "Decoding Global Talent, Onsite and Virtual."

[10] National Security Commission on Artificial Intelligence, "Final Report."

[11] McCaul et al., "China Task Force Report."

[12] Akcigit et al., "Immigration and the Rise of American Ingenuity." And UNESCO, "Immigrant Nobels Lead the Way."

[13] For comparison, only 34% of advanced STEM workers outside the defense industrial base are foreign-born. Author's analysis of microdata from the U.S. Census Bureau's American Community Survey, using the 2015-2019 five-year sample. University of Minnesota, IPUMS USA. Following the "Vital Signs 2020" report, I used the following industries as defense industrial base industries (also called defense-related industries): selected durable industrial goods manufacturing: (NAICS codes: 325M, 3252, 3255, 326, 327, 331, 332, 333, 335, 336), selected information and communication technologies (NAICS 334, 5112, 517,



However, existing restrictions on STEM immigration — and the resulting backlogs and waiting times for STEM talent — hamper the defense industrial base's growth. Without reducing the barriers to high-skilled immigration, efforts to onshore and strengthen critical industries in the United States will face significant hurdles, and may fail altogether.

The Department of Defense has concluded that the defense industrial base "faces problems that necessitate continued and accelerated national focus over the coming decade" and specifically that "the workforce on which a defense industrial renaissance would depend has become…an endangered species."[14] An industry report concluded that "workforce challenges and the availability of talent are a critical concern," finding that 82% of companies in the defense industrial base report that it is difficult to find qualified STEM workers that they need.[15]

While only one in twelve Americans work in the major industries that comprise the defense industrial base, more than one in five with advanced STEM degrees do.[16] Three times as much of the workforce in the defense industrial base have advanced STEM degrees as in other industries.[17]

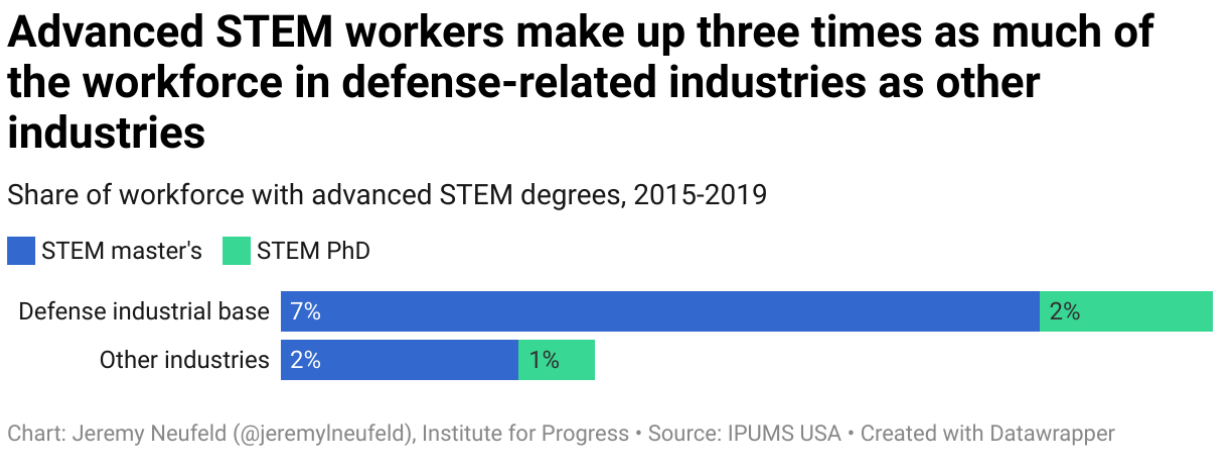
518, 5415) and scientific research and development (NAICS 5417). STEM degree fields are matched as closely as possible to DHS, "STEM Designated Degree Program List."

[14] Department of Defense, "Fiscal Year 2020 Industrial Capabilities Report to Congress."

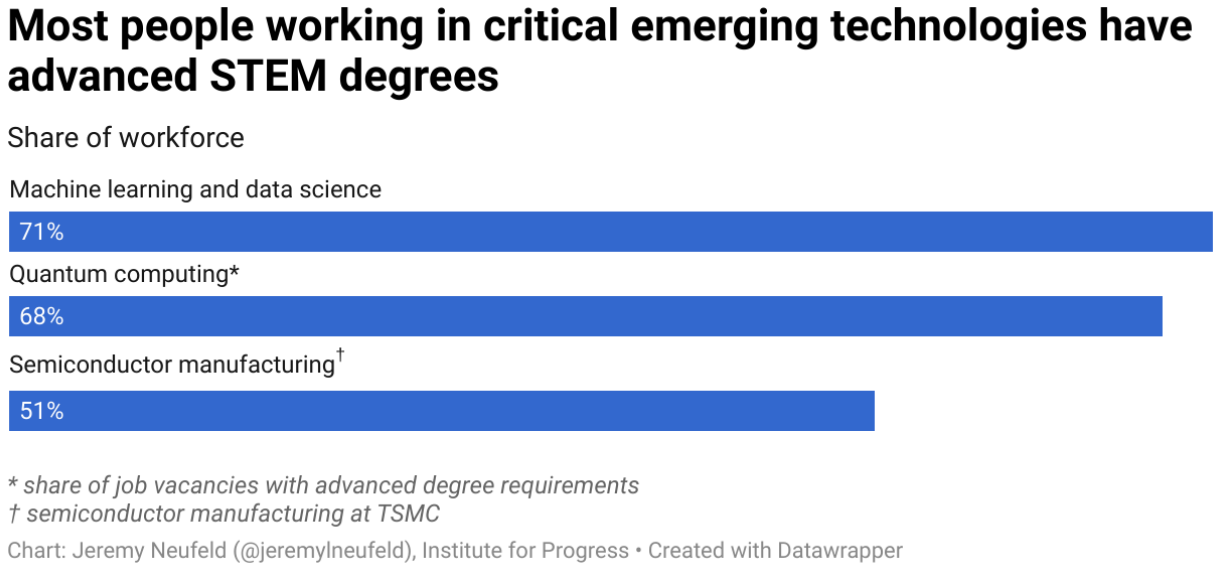
[15] NDIA and Govini, "Vital Signs 2020: The Health and Readiness of the Defense Industrial Base."

[16] Author's analysis of data from University of Minnesota, IPUMS USA. See above.

[17] Ibid.



The reliance on advanced STEM degrees is all the more striking in cutting-edge technologies. More than 50% of the workforce for the world's leading semiconductor manufacturer have advanced degrees.[18] 68% of job vacancies in quantum computing require advanced degrees.[19] And more than 70% of the machine learning and data science workforce (key in artificial intelligence) have advanced degrees.[20]



STEM master's graduates are crucial for practically applying research

PhDs are central to research and development, but bringing cutting-edge ideas into practical use in industry and military applications also requires a strong base of STEM master's talent.

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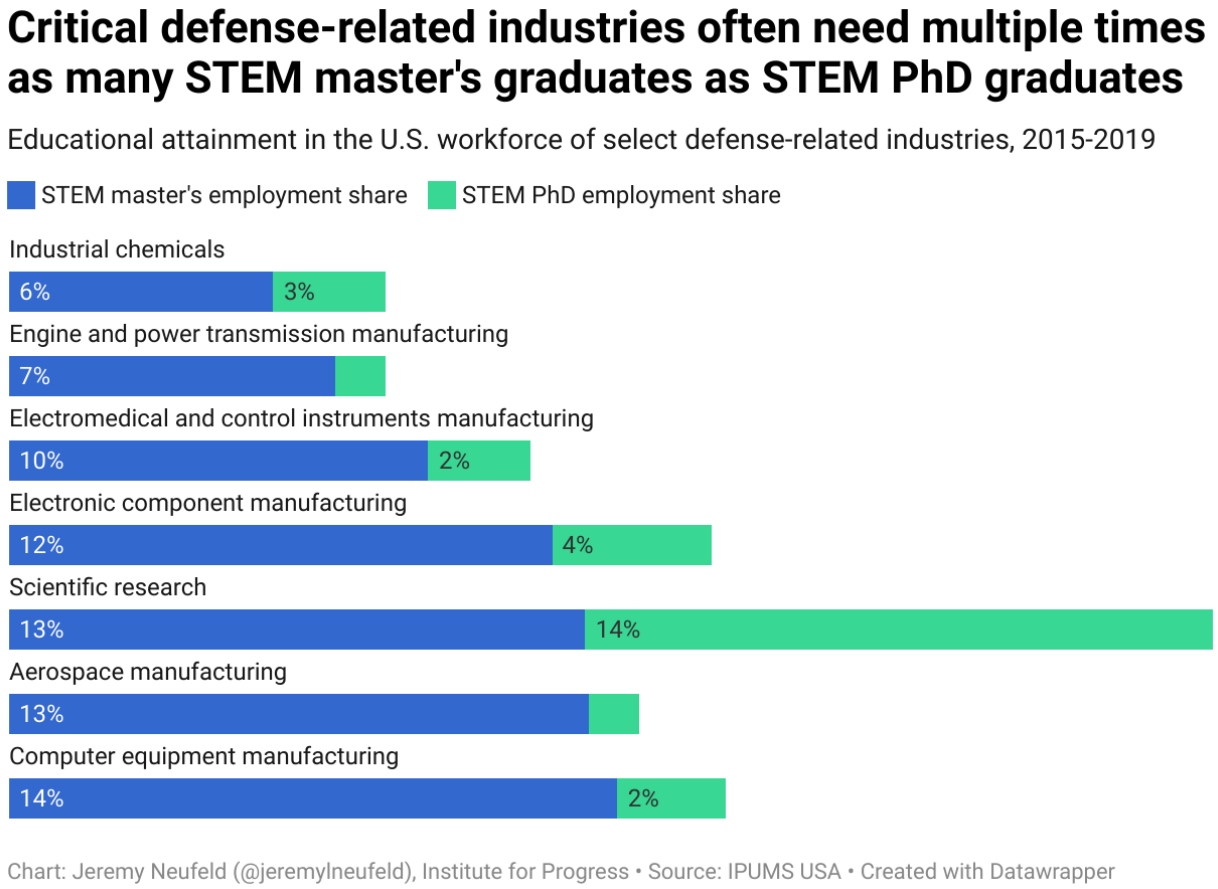
[18] Taiwan Semiconductor Manufacturing Company, "TSMC Annual Report 2020 (I)."
[19] Kaur and Venegas-Gomez, "Defining the Quantum Workforce Landscape."
[20] Kaggle, "Kaggle's State of Data Science and Machine Learning 2019."

While previous legislation on top STEM talent has focused on PhDs,[21] America COMPETES also exempts certain STEM masters graduates. These exemptions apply only to those graduates who work in industries that are critical for U.S. national and economic security.[22]

Many defense-related industries that are essential to our national security, like semiconductor fabrication or aerospace manufacturing, need highly technical, experienced workers with advanced degrees but not necessarily PhDs. In these industries, a master's exemption can unlock growth potential that a PhD exemption couldn't alone. Not only would critical industries be able to draw on a larger pool of qualified talent, they would be able to bring in experienced workers whose soft-skills and tacit knowledge cannot be acquired by additional years of school and are necessary to onshore industries reliant on highly technical skilled work.

As can be seen in the chart below, U.S. Census Bureau data show that critical industries in the defense industrial base often rely on multiple times as many STEM master's graduates as STEM PhD graduates.



[21] For instance, see the bipartisan STAPLE Act. H.R. 2717, 115th Congress.
[22] Which industries will be considered "critical" will be decided by the Assistant Secretary of the Office of Supply Chain Resilience and Crisis Response and will likely be similar to defense industrial base industries.

The importance of the master's exemption for critical industries is even more striking in critical emerging industries narrower than are available in IPUMS data used above. In artificial intelligence, an industry report from 2019 shows 19% of the data science and machine learning workforce have PhDs, but more than 52% have master's degrees.[23] In semiconductor fabrication, the workforce has over nine times as many master's degree holders as PhDs.[24] In short, a master's exemption for critical industries will be a significant force multiplier in ensuring the workforce needs of the defense industrial base are met.

Reshoring semiconductor fabrication

As the United States looks to reverse its declining relative capacity in semiconductor fabrication through the CHIPS Act, it will need to attend to workforce concerns that, at least for the foreseeable future, are insurmountable without changes to immigration policy. Recent findings by the Center for Security and Emerging Technology suggest that there is "insufficient semiconductor manufacturing talent latent in the U.S. workforce" to meet the labor needs of new fabs funded by the provisions which are likely to be included in the final version of the Bipartisan Innovation Act.[25]

Semiconductor fabrication requires a highly educated STEM workforce, but U.S. industry has faced a persistent STEM talent shortage.[26] This shortage has been strongly felt in the semiconductor industry, where industry insiders report that "the talent shortage is the most critical issue confronting the semiconductor industry today."[27] A report on attracting and retaining talent by the Taiwan Semiconductor Manufacturing Company (TSMC) shows that a majority of their workforce has an advanced degree, with less than 5% of TSMCs workforce having PhDs, but 47% having master's degrees.[28]

But increasing educational attainment of natives and recruiting and retaining highly educated international talent will only go so far in expanding U.S. capacity. Semiconductor fabrication doesn't only require a highly-educated workforce, it relies on workers with semiconductor-specific experience. As the Semiconductor Industry Association explained to the National Institute of Standards and Technology in 2018, bringing experienced workers is vital for new fabs because "new recruits often lack the skills to 'hit the ground running.'...Many students graduating from U.S. colleges and universities with excellent general engineering or computer science skillsets often lack industry specific skills and the broader set of 'soft skills' required to work effectively."[29]

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[23] Kaggle, "Kaggle's State of Data Science and Machine Learning 2019."
[24] Taiwan Semiconductor Manufacturing Company, "TSMC Annual Report 2020 (I)."
[25] Will Hunt, "Reshoring Chipmaking Capacity Requires High-Skilled Foreign Talent: Estimating the Labor Demand Generated by CHIPS Act Incentives."
[26] Xue and Larson, "STEM crisis or STEM surplus? Yes and yes."
[27] Ajit Manocha, quoted in Information Technology and Innovation Foundation, "Comments to the Department of Commerce."
[28] Taiwan Semiconductor Manufacturing Company, "TSMC Annual Report 2020 (I)."
[29] Semiconductor Industry Association, "Comments to the National Institute of Standards and Technology on 'Current and Future Workforce Needs to Support a Strong Domestic Semiconductor Industry.'"

The vast majority of workers with the necessary experience are outside the United States. The U.S. share of global capacity for semiconductor manufacturing stands at just 12%, dwarfed by semiconductor manufacturing capacity in East Asia.

Even those new roles that can be filled by STEM graduates without experience must be trained by those with experience. And in any case, the majority of advanced STEM degrees in the relevant fields go to international students,[30] who must be able to secure visas if new semiconductor fabs in the United States are going to be able to employ them.

In Arizona, where TSMC is building a $12 billion dollar fab, progress has reportedly been delayed by three to six months in large part by an inability to fill engineering jobs.[31] Last year, Morris Chang, the founder of TSMC, identified talent shortages in the United States as the major challenge to opening fabs here.[32]

The artificial scarcity of semiconductor talent is already a major challenge in growing U.S. semiconductor capacity and will only get worse if the U.S. funds new fabs without exempting advanced STEM degree holders in the field from visa caps. Cap exemptions would help ensure the Bipartisan Innovation Act's new investments in semiconductor fabs ultimately pay off.

Conclusion

America's ability to attract the world's leading minds has long been an asymmetric advantage. But backlogs, waitlists, bureaucracy, and restrictions have cut into the United States' historical leadership as talented foreigners have increasingly sought opportunities abroad rather than navigate America's hostile immigration system.

The Department of Defense's Industrial Capabilities Report put it well when it said "the most important asset our defense industrial base possesses isn't machines or facilities, but people…Greater attention must be paid to workforce concerns…to maintain and develop the intellectual capital necessary to create and sustain war-winning weapon systems for the modern battlefield."[33]

Addressing such workforce concerns practically means both investing in domestic education and training as well as targeted reforms to immigration policy. Fortunately, both the House and Senate versions of the Bipartisan Innovation Act include much-needed funding for upskilling Americans and so domestic workforce development is almost certain to make it into the final bill. But the prospects are far more uncertain for provisions to better recruit and retain highly skilled STEM talent.

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[30] Will Hunt, "Reshoring Chipmaking Capacity Requires High-Skilled Foreign Talent: Estimating the Labor Demand Generated by CHIPS Act Incentives."
[31] Ting-Fang et al., "Construction of TSMC's U.S. chip plant delayed by labor crunch, COVID."
[32] Chen, "TSMC founder doubts US competence in chip-making."
[33] Department of Defense, "Fiscal Year 2020 Industrial Capabilities Report to Congress."

We already educate much of the world’s top talent in U.S. universities. The fact our immigration laws prevent us from keeping more of them here is a detriment to our security and competitiveness.