Meeting US Defense Science and Engineering Workforce Needs: A Progress Report

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Abstract

Recent years have seen growing recognition of the deep reliance of the US national security innovation base on foreign national advanced degree holders in the fields of science, technology, engineering, and mathematics (STEM). This recognition has led to a number of executive and legislative branch efforts aimed at attracting and securing highly skilled foreign-born STEM advanced degree holders to the United States, as a potential path forward for meeting the science and engineering workforce needs of the US defense sector and its associated innovation base. This paper describes the policy context for this shift and highlights ongoing needs for improved data and research that we see as critical for informing evidence-based policy debates in the coming years.

JEL Codes: F52, K37, J68, J61

Keywords: national security, innovation base, high-skilled, immigration, STEM talent

I. Introduction

Over the past several decades, economic research has shed light on many aspects of the economics of immigration. Led by Chiswick (1978), economists have analyzed how length of time in the United States—often referred to as assimilation—affects the earnings of migrants to the United States. Building on Borjas's (1987) classic application of the Roy model, economists have analyzed the role of self-selection in which individuals migrate across countries. Work by Card (1990) and others has sought to

Entrepreneurship and Innovation Policy and the Economy, volume 4, 2025.
 https://doi.org/10.1086/732857

provide rigorous evidence on how immigrants affect the wages and employment of natives. Economists have also directly studied several immigration policies, such as the H-1B visa lottery (Doran, Gelber, and Isen 2022, Mahajan et al. 2024). Many economists are drawn to work on the economics of immigration out of a desire to generate rigorous, policy-relevant evidence that can inform both policy makers and the public about how changes to immigration policies affect the number and characteristics of foreign nationals allowed to enter the United States, and on the economic impacts of those changes.

To be clear, this past literature has generated a number of important facts and insights. However, in recent years the key policy efforts aimed at changing the number and characteristics of foreign nationals allowed to enter the United States have been raised not in the context of immigration policy discussions but rather have been articulated by the national security community as potential pathways for meeting the science and engineering workforce needs of the US defense sector. Most of the economists with relevant expertise—in the economics of immigration—seem to be largely unaware of these national security-related efforts, presumably in part because economists have generally played less of a role in national defense and national security policy discussions. As a result, economics research has largely failed to keep pace with producing the types of facts and evidence that are needed to lay the groundwork for informed policy decisions in this area. The goal of this paper is to provide some context for this recent set of executive and legislative branch efforts and to highlight specific examples of topics where additional research by economists would be valuable for informing more evidence-based policy discussions in the coming years.

It would be remiss not to mention that although national defense and national security have long been core policy objectives for politicians across the political spectrum, the economics of defense and national security are topics that have generally been neglected by economists relative to the policy attention they receive. From a public finance perspective, national security can be conceived of as an investment in a public good designed to reduce the likelihood of large-scale societal losses. Congressional interest in national security as a policy objective can be illustrated concretely with data on budgetary outlays, with Congress appropriating hundreds of billions of dollars annually. When economists such as the late Harvard economist Martin Feldstein have encouraged economics PhD students to pursue research on the economics of national security, they have generally guided students toward researching topics

such as military compensation, analysis and prediction of armed conflicts, and terrorism.[1] Although such topics are obviously quite important, the topic of focus here—namely, the heavy reliance of the US national security innovation base on foreign national science, technology, engineering, and mathematics (STEM) advanced degree holders—has thus far not been a focus of researchers working on the economics of national security.[2]

II. Policy Context

It was evident the national security policy discussion was connected to innovation and international talent at least by the time the White House National Science and Technology Council (NSTC) released its report on "A 21st Century Science, Technology, and Innovation Strategy for America's National Security" (National Science and Technology Council 2016b). This NSTC report argued: "The institutions that contribute to the national security science, technology, and innovation infrastructure should be, wherever possible, able to draw on the world's best and brightest minds regardless of citizenship" (National Science and Technology Council 2016b, 12) and that "sensible immigration policies, including for skilled immigrants in specialty technical areas, particularly for those educated in US universities, must continue to be a goal" (National Science and Technology Council 2016b, 14). Notably, the discussion was largely framed in terms of workforce dynamics. For example, later that same year another NSTC report (National Science and Technology Council 2016a), this one focused on strategic planning on artificial intelligence R&D, argued that "while no official AI workforce data currently exist, numerous recent reports from the commercial and academic sectors are indicating an increased shortage of available experts in AI. . . . Additional studies are needed to better understand the current and future national workforce needs for AI R&D."

A few years later, the Center for Security and Emerging Technology (CSET) was founded at Georgetown University, which would take the lead on—among other topics—both original research and synthesis of existing data on this topic. For example, CSET's 2019 report "Immigration Policy and the US AI Sector" (Arnold 2019) quantified the importance of immigrant talent to the AI industry and argued that US immigration policies were lagging behind policies of peer countries in the race for talent. In testifying in a hearing on AI and the workforce (House Budget Committee 2020), the founding director of CSET accentuated

the necessity of inserting immigration into the discussion by explaining that: "We should ensure that we remain an attractive destination for global talent by broadening and accelerating the pathways to permanent residency for scientists and engineers" (House Budget Committee 2020, 58).

Later that year, the Future of Defense Task Force (2020) of the House Armed Services Committee connected these threads by recommending the United States invest in domestic STEM primary education; attract and retain foreign STEM talent, including supporting H.R. 7256 (116th, National Security Innovation Pathway Act), discussed below; and improve federal government hiring for STEM talent including at the Pentagon. When the National Security Commission on Artificial Intelligence issued its final report the following year, both immigration and workforce recommendations were extensively featured (National Security Commission on Artificial Intelligence 2021). The AI Commission made numerous recommendations on the necessity of cultivating more domestic talent, discussing the needs of US markets as well as those of the national security enterprise. Moreover, the commission argued that immigration reform is a national security imperative, associating the value of attracting and retaining highly skilled individuals to gaining strategic and economic advantages over competitors. As the president's national security adviser remarked at the AI Commission's global emerging technology summit, "We have to [ensure] it's easier for America to be the destination of choice for the best and brightest scientists and technologists around the world" (White House 2021).

Artificial intelligence is of course just one of many strategically significant industries. O'Brien and Ozimek (2024) spell out the inherent reasoning animating the connection points between talent, innovation, and economic competitiveness in a range of sectors: strategic industries are increasingly reliant on highly skilled workers (the share with a graduate degree grew from 12.4 to 19.6% since 2000), and foreign-born workers account for a disproportionate and increasing share of highly skilled workers in strategic industries (growing from 26 to 36% since 2000). India and China are the largest source countries for skilled foreign-born professionals in strategic industries in the United States, comprising more than 40% of college-educated workers, despite facing the tightest country-specific caps on employment-based green cards. Overall, despite representing 14% of the US population, foreign-born experts comprise 37% of the workforce with advanced STEM degrees for US Department of Defense-funded (DoD) projects (Miles, Chase, and Neufeld, forthcoming).

Moreover, many more advanced STEM degree immigrants are engaged in broader US-based research and development initiatives advancing US technological development beyond those directly funded by the DoD, in scientific development and engineering services generally and in many specific industries—including electronics manufacturing, space research, and aerospace and aircraft manufacturing.

These realities have led many national security experts to conclude that congressional action is needed to encourage additional foreign national STEM advanced degree holders to be admitted to the United States, as evidenced by the concerns expressed by more than 45 national security experts and officials from both Democratic and Republican administrations in a letter in the last (117th) Congress to congressional leadership (Snyder and Allen-Ebrahimian 2022).

This focus on critical and emerging technologies (National Science and Technology Council 2024) in DoD-funded activities is more broadly consistent with a changing target of federal support for the national defense, which incorporates innovation and economic competitiveness. Instead of defense funding to support DoD narrowly, there is a movement toward a much broader conceptualization of the US national security innovation base. As described by the Congressional Research Service (2023), during the first 150 years of its history, the United States devoted relatively few resources to the management and maintenance of a permanent defense industrial base. Dating back roughly to America's entry into World War II, the concept of a defense industrial base—generally used to refer to a broad set of organizations that supply the US government, primarily but not exclusively the DoD, with materials and services for defense purposes—has featured much more centrally in national security and national defense policy discussions. In recent years, the policy emphasis has shifted further toward what is often described as the national security innovation base. To reference one definition from the Ronald Reagan Presidential Foundation and Institute, the national security innovation base is defined as a broad array of actors including various research centers and laboratories, universities and academia, venture capital, and the innovative systems of American allies and partners, noting, "In order to sustain America's competitive advantage and to achieve its national security objectives, the common purpose and coordinated efforts of these key stakeholders are vital." (Ronald Reagan Presidential Foundation & Institute 2024) The 2022 National Defense Strategy (US Department of Defense 2022) is one recent federal agency document echoing this focus, noting, "We will act urgently to build enduring

advantages across the defense ecosystem—the Department of Defense, the defense industrial base, and the array of private sector and academic enterprises that create and sharpen the Joint Force's technological edge."

Thus, industries producing goods or services critical to national defense are often the leading examples, but from a policy perspective these are frequently addressed together with goods such as semiconductors that are also strategically significant—for a variety of reasons including supply chain dynamics (Hunt and Zwetsloot 2020). Neufeld (2022) argues that looking at strategic technology sectors, the workforce share with advanced STEM degrees is often quite high: around 50% of the workforce at Taiwan Semiconductor Manufacturing Company (Taiwan Semiconductor Manufacturing Company 2020), and around 70% for quantum computing (Kaur and Venegas-Gomez 2022) as well as machine learning and data science (Kaggle 2019).

The shift in emphasis toward strategic innovation and economic competitiveness has resonated in particular in recent thinking about China, including a focus on the talent nexus. Zwetsloot et al. (2021) is one recent analysis comparing the STEM PhD pipelines of the United States and China. Figure 1 documents that since around 2005, China has consistently produced more STEM PhDs than the United States, with a gap

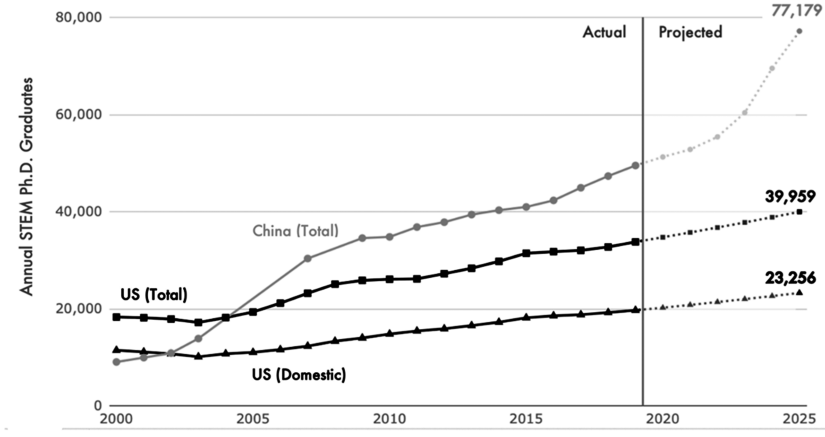

Fig. 1. China projected to nearly double US science, technology, engineering, and mathematics (STEM) PhD graduates by 2025. This replicates figure 1 of Zwetsloot et al. (2021), for which the underlying data are the National Center for Education Statistics' Integrated Postsecondary Education Data System (IPEDS) for US data and Ministry of Education for Chinese data (see their app. A for details). The US (Domestic) series aims to remove international students from the US (Total) series. Color version available as an online enhancement.

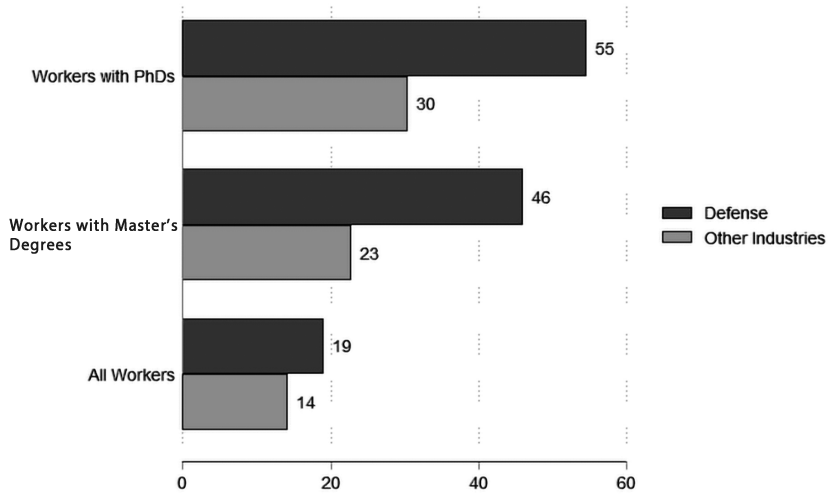

Fig. 2. Reliance on foreign-born science, technology, engineering, and mathematics (STEM) talent, defense-related industries versus other industries. This replicates an unnumbered figure from Neufeld (2022) using Integrated Public Use Microdata Series (American Community Survey) data. STEM fields are matched to the DHS STEM Designated Degree Program List: 11, 13, 20, 21, 24, 25, 36, 37, 38, 50, 51, 52, 55, 59, 61. For defense industries, following the National Defense Industrial Association (2020) we use the following industries as defense industrial base industries (also called defense-related industries): selected durable industrial goods manufacturing: (North American Industry Classification System [NAICS] codes: 325M, 3252, 3255, 326, 327, 331, 332, 333, 335, 336), selected information and communication technologies (NAICS 334, 5112, 517, 518, 5415), and scientific research and development (NAICS 5417). The classification of DHS STEM Designated Degree Program List is likely not a perfect match with Neufeld (2022), but the graph closely resembles Neufeld's figure. Color version available as an online enhancement.

that has widened—and, based on current enrollment patterns, is projected to continue to widen—over time. If international students are excluded from the US count, Chinese STEM PhD graduates would outnumber their US counterparts more than three to one.

As the House China Task Force (2020) found in its report, and as documented in Figure 2, the data show that in the near and medium terms the United States will remain reliant on foreign talent, and thus the United States must compete in the global race for talent and both attract and retain the best and brightest immigrant minds to contribute to the US economy and drive US productivity. A December 2023 report from the House Select Committee on the Strategic Competition Between the United States and the Chinese Communist Party—"Reset, Prevent, Build: A Strategy to Win America's Economic Competition with the Chinese Communist Party" (US House of Representatives 2023)—describes 150 policy

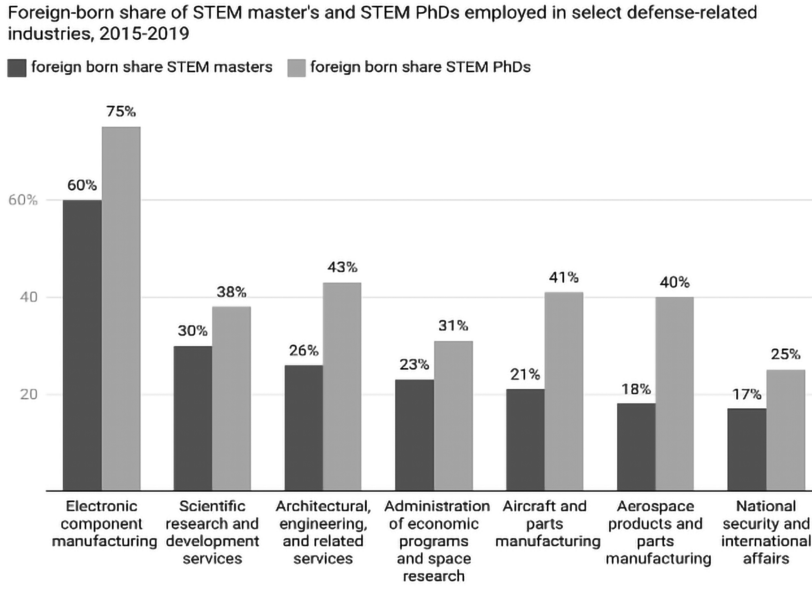

Fig. 3. Reliance on foreign-born science, technology, engineering, and mathematics (STEM) talent, by sector. From Miles, Chase, and Neufeld (forthcoming). Color version available as an online enhancement.

recommendations to embrace "the clear reality that our current economic relationship with the People's Republic of China needs to be reset in order to serve the economic and national security interests of the United States." The report's recommended investments in technological leadership and economic resilience center on addressing concerns that the United States is "falling behind in the race for leadership in certain critical technologies," and that China is "gaining on the US in the race for global talent." The realities of global talent in US defense-related industries are reflected in Figure 3. The bipartisan recommendations also highlight that screening and vetting concerns need to be applied in ways that allow the United States to make progress with partners on collaborative efforts on critical and emerging technologies and should include a work authorization program for STEM experts from such allied nations (US House of Representatives 2023).

Through both Republican and Democratic control of the presidency and chambers of Congress, the issue is now joined and is understood to require a whole-of-government approach (Future of Defense Task Force 2020, Senate Armed Services Committee 2020).

Basics of US High-Skilled Immigration

With regard to permanent residency, lawful permanent resident status is often referred to as "green card" status. In the system of preferences set out by Congress for immigrant classification, there are only three preference categories where immigrants are selected because of their education, experience, and future employment in the United States. These employment-based green cards for workers are the Employment-Based First Preference (EB1), Employment-Based Second Preference (EB2), and Employment-Based Third Preference (EB3) categories, subject to both worldwide and per country numerical limits, set in 1990 to reflect circumstances 35 years ago.

EB1 includes individuals of extraordinary ability in any field along with professors and researchers in academia, among others. EB2 includes advanced degree professionals, or individuals with a bachelor's degree and at least five years of progressively responsible experience. EB3 includes, among others, any professional working in a job requiring at least an undergraduate degree. EB2 and EB3 require a lengthy certification process at the Department of Labor that such job offer to a foreign national will not negatively affect the US labor market, unless either the work is in the national interest, in which case a National Interest Waiver (NIW) can form the basis of EB2 classification, or the type of employment is identified on so-called Schedule A confirming the relative scarcity of qualified US workers, allowing EB2 or EB3 petitions without an individualized labor certification.

Obtaining a lawful temporary status while assessing if, when, or how to pursue permanent residency is a necessity for foreign-born scientists, technologists, and engineers. However, many temporary visa categories have numerical caps, short maximum periods of stay, or treaty-based restrictions on nationality. Those temporary visa categories generating the most interest include: H-1B (professionals in a specialty occupation)—allows indefinite extensions if in the process for permanent residency; O-1A (extraordinary ability individuals)—has no numerical limit or maximum period of stay; J-1 researcher (can include STEM professionals at companies supporting industry R&D)—has no numerical limit and allows up to five years of status; and F-1 student (Optional Practical Training [OPT] allows postcompletion employment related to degree)—provides up to three years of work authorization for STEM grads without numerical limit.

III. Executive and Legislative Branch Efforts

A. Regulatory and Statutory Framework for Attracting and Retaining Foreign National STEM Advanced Degree Holders

The US immigration framework for selecting immigrants based on their skills, education, talents, and future employment contributions to the United States continues to be based on the construct of the original Immigration and Nationality Act (INA) of 1952, last comprehensively updated in 1990 act amendments to the INA when most of the present numerical limits were adopted (Bier 2023). In this same era, Congress took note in 1950, when it established the National Science Foundation (NSF), that the science and engineering workforce was key to US interests in fostering innovation, economic competitiveness, and national security (National Science Board 2015), but this did not come with a companion expectation that such vital US interests required the nation's immigration rules and statutes to systematically provide access to foreign national STEM advanced degree holders who wanted to become Americans. Likewise, the 1990 act amendments, including numerical caps, were developed before the STEM acronym became a standard reference at NSF, when the nation's population was three-quarters of its current size, and when the real gross domestic product of the US economy was half its current size. And the last prepandemic year of data shows that in the 30 years following the 1990 act the number of international students earning degrees at US institutions of higher education increased by more than 300%, about half in STEM (Congressional Research Service 2019). Layering in today's national security imperatives to retain foreign-born scientists, technologists, and engineers, the outdated regulatory and statutory immigration framework creates challenges.

B. Recent Government Actions

Awareness of the vital role international STEM talent plays in driving interconnected economic and national security has resulted in both the executive and legislative branches making recent efforts. Over the last three years, the executive branch has sought to improve use of existing agency authorities that relate to international STEM talent, and the prior two Congresses have seen the development of legislative language specifically targeting more access to lawful permanent resident status (green card status) for foreign-born STEM advanced degree holders.

Most recently, departments and agencies have adopted an approach of announcing policy guidance (White House 2022) to explain which international STEM experts qualify for status and US employment under existing binding regulations (Rampell 2022). As summarized in table 1, the approach has been used for STEM OPT (the postcompletion OPT program for STEM graduates of US universities), O-1A status (the visa category for noncitizens with extraordinary ability), classification as an EB2 immigrant based on NIW, and the J-1 Early Career STEM Research Initiative (exchange visitors at companies instead of just on campuses pursuing scholarly research).

STEM OPT Guidance from Department of Homeland Security on Degree List Updates

OPT by default allows up to 12 months of employment in the US postgraduation, and STEM graduates are eligible for a 24-month extension (so 36 months total). An annual nominations process allows the US Department of Homeland Security (DHS) to keep the STEM OPT extension-qualifying degree list (called the Designated Degree Program List; https://www.ice.gov/doclib/sevis/pdf/stemList2023.pdf) up to date over time.

O-1A Guidance from DHS

O-1A nonimmigrant status is available to people with "extraordinary ability" measured by achievements in science, business, education, or athletics. In January 2022, US Citizenship and Immigration Services (2022a) provided guidance on O-1A eligibility, including clarifications and examples for STEM PhD graduates. Importantly, O-1A visa disbursement is uncapped, but tabulations of foreign-born STEM PhD graduates against O-1A take-up suggest this pathway is underutilized.

NIW Guidance from DHS

The NIW EB2 advanced degree immigrant category allows certain highly qualified people to self-petition for a green card. In January 2022, US Citizenship and Immigration Services (2022b) provided guidance on how STEM master's or PhD graduates may qualify for eligibility based on the merit of their work and relevance of their work to national interests (e.g., if they are poised to make contributions in a critical or emerging technology field).

Table 1
Selected Actions by Departments and Agencies Targeting Foreign National Advanced STEM Degree Holders

Agency Policy	Action	Benefits	Prospects and Limitations
STEM OPT DHS guidance STEM OPT Degree List Update 2022[b] STEM OPT Degree List Update 2023[c]	Update the Designated Degree Program List[a] for postcompletion STEM OPT adding 22 fields in January 2022 and eight fields in July 2023, to reflect new, largely multidisciplinary fields of study, expanding the STEM fields in which international students may remain in the United States and work after earning a US STEM degree.	OPT for STEM grads allows up to three years of employment in the United States after graduation. The annual nominations process will allow DHS to keep the degree list current for STEM OPT.	DHS SEVP is fast approaching a modernized degree list for STEM OPT, absent future changes by the National Center for Education Statistics adding new fields to or otherwise revising the CIP.
O-1A DHS guidance O-1A Policy Manual[d] Guidance and Appendix, 2022	January 2022 USCIS Policy Manual update that, for the first time since the O-1A category was created by Congress in 1990, provides written guidance as to how STEM PhDs may qualify, by updating the USCIS Policy Manual, including an appendix table, to clarify for both agency adjudicators and stakeholders how USCIS evaluates evidence to determine eligibility for O-1A nonimmigrants of extraordinary ability.	The O-1A nonimmigrant visa category for extraordinary ability is uncapped, without any per country limits, with no maximum period of stay.	Even after new policy guidance, O-1A uptake for STEM activities represents only about 10% of foreign-born STEM PhDs in the United States earning doctorates and completing postdoctoral fellowships, which suggests it remains underused. (Each year in the United States there are just under 14,000[e] international students earning a PhD and around 35,000[f] international STEM PhD holders participating in a postdoc, whereas FY23 data show 4,560[g] O-1A petitions approved for STEM activities.)

NIW DHS guidance NIW Policy Manual[h] Guidance, 2022	January 2022 USCIS Policy Manual update that, for the first time since the NIW category for green card eligibility was created by Congress in 1990, provides written guidance on how STEM master's or PhD graduates may qualify for green card eligibility if their work is of substantial merit and in the national interest, by updating the USCIS Policy Manual to address requests for NIWs for advanced STEM degree professionals, providing some objective criteria for when work is typically in the national interest, such as when a noncitizen is working in a critical and emerging technology field[i] or an endeavor tied to the annual R&D priorities[j] identified by the OSTP and OMB.	Individuals approved for NIW classification for Employment-Based Second Preference advanced degree immigrants are largely self-petitioned and not tied to a sponsoring employer for their permanent residency process, and they are the beneficiaries of a more certain and timely process to secure eligibility confirmation from DHS.	Only Congress can create more immigrant visa numbers for green card status. Thus, even if receiving NIW approval as an individual making contributions to an endeavor in the national interest like critical and emerging technologies, one cannot obtain final lawful permanent resident status any faster than congressionally mandated worldwide limits and per country caps provide.
J-1 Researcher DOS guidance Early Career STEM Research Initiative, 2022[k]	Utilize existing State Department regulations governing exchange programs for researchers and scholars, to allow entities designated by State, including universities as well as nonprofits, to sponsor foreign researchers to be employed in private industry STEM R&D, including technology ventures spun off by universities to commercialize technology. The STEM Initiative explains that foreign-born STEM experts, at all academic levels, may be in the United States to conduct and participate in STEM R&D efforts, hosted by industry on J-1 visas, including STEM postdocs who do not need to be solely on campus.	J-1 visas for researchers carry a five-year validity period, without a congressionally established numerical limit or per country caps. Significant numbers of foreign-born STEM master's and PhD graduates could be hosted by companies, adding a global perspective to R&D teams at US firms. Relevant given that about 90% of experimental STEM development in the United States and approaching 60% of US applied STEM research is funded by and performed by companies.	Although the goals of the J-1 exchange visitor program to promote the exchange of ideas fit nicely with the nature of scientific inquiry, exchange visitors are required to intend to return home and many individual J-1 visa holders are subject to a two-year home residency requirement based on the Skills List, including almost all scientists, technologists, and engineers from India and China.

Table 1
Continued

Agency Policy	Action	Benefits	Prospects and Limitations
H-1B research cap exemptions DHS regulation H-1B Modernization[m] NPRM, 2023 (at p. 72883–86 and 72962–63 of NPRM)—in process	EO 14410,[l] at Section 5.1(d), requires the DHS to continue its rulemaking process to modernize the H-1B program and enhance its integrity and usage.	The NPRM includes a proposal to clarify whenever research is a fundamental activity of a nonprofit that organization might qualify as an H-1B cap-exempt entity and whenever industry partners with nonprofit or university research and an H-1B professional employee of a company spends at least 50% of their time on that collaborative effort that individual might be cap exempt.	Final rule expected later in calendar year 2024.
J-1 Exchange Visitor Skills List DOS regulation Final rule at OIRA[n] for review, 2024—in process	EO 14410,[l] at Section 5.1(b), requires the State Department to consider rulemaking establishing new criteria to designate countries and skills on the Exchange Visitor Skills List as it relates to the two-year foreign residence requirement, including those skills that are critical to the United States, and consider publishing updates to the 2009 Skills List.	The Skills List applies when DOS finds that skills being developed in the United States by a J-1 visa holder are "clearly required" for the development of the J-1 visa holder's home country. Currently 82 countries have chosen to participate in the Skills List. A revised Skills List methodology might allow more STEM experts from more countries to follow the science, technology, or engineering wherever it takes them.	Final rule on Skills List methodology expected spring 2024, with updated Skills List expected to follow.

Schedule A DOL regulation RFI 2023[o]—in process	EO 14410,[l] at Section 5.1(e), requires the DOL, for purposes of considering updates to the so-called Schedule A list of occupations, to publish an RFI to identify AI and other STEM-related occupations for which there is an insufficient number of ready, willing, able, and qualified US workers.	A modernized Schedule A utilizing a self-executing, data-based methodology to identify types of employment for which there is relative scarcity in the United States would allow a streamlined permanent residency process for those noncitizens working in those occupations, and would help the United States understand educational or skills gaps to improve training and education for the domestic workforce.	RFI will close in May 2024; unclear what DOL will do next.

Note: Table 1 was compiled by the author, based on the regulatory and policy text sources referenced in the table. DHS = Department of Homeland Security; SEVP = Student and Exchange Visitor Program; CIP = Classification of Instructional Programs; DOL = Department of Labor; DOS = Department of State; NIW = National Interest Waiver; OIRA = Office of Information and Regulatory Affairs; OMB = Office of Management and Budget; OPT = Optional Practical Training; OSTP = Office of Science and Technology Policy; STEM = science, technology, engineering, and mathematics; USCIS = US Citizenship and Immigration Services; NPRM = Notice of Proposed Rule Making; RFI = Request for Information.

[a]US Department of Homeland Security 2023a.
[b]US Department of Homeland Security 2022.
[c]US Department of Homeland Security 2023c.
[d]US Citizenship and Immigration Services 2022a.
[e]National Science Board 2022.
[f]National Science Foundation 2023.
[g]US Citizenship and Immigration Services 2024b.
[h]US Citizenship and Immigration Services 2022b.
[i]National Science and Technology Council 2024.
[j]Executive Office of the President: Office of Management and Budget 2023.
[k]US Department of State 2022.
[l]Executive Order of October 30, 2023.
[m]US Department of Homeland Security 2023b.
[n]Executive Office of the President 2024.
[o]US Department of Labor 2023.

J-1 Researcher Guidance from Department of State

The J-1 exchange visitor program authorizes people to—among other things—study, teach, research, or intern in the United States (described by US Citizenship and Immigration Services 2023). The Department of State (DOS)–led (US Department of State 2022) Early Career STEM Research Initiative connects sponsoring firms and research organizations with J-1 visa holders who seek STEM research experience with industry. J-1 researchers are expected to return home after visa expiration (five-year maximum) and are often subject to the two-year home residency requirement.

H-1B Research Cap Exemptions Regulation from DHS

H-1B cap-exempt employers include institutions of higher education, nonprofit entities affiliated with institutions of higher education, and nonprofit research or governmental research organizations. The rulemaking required by the Executive Order of October 30 (2023) includes clarification on cap exemption for nonprofits where research is a central focus and for employees at for-profit firms that collaborate with university-based or nonprofit research organizations.

J-1 Exchange Visitor Skills List Regulation from DOS

The Exchange Visitor Skills List details the "specialized knowledge and skills that are deemed necessary for the development of an exchange visitor's home country" (US Department of State 2009). The Executive Order of October 30 (2023) requires the DOS to consider criteria to update countries and skills on the Skills List, as it relates to the two-year home residency requirement. A revised list has the potential to broaden the scope and quantity of exchange visitors to the United States, especially in STEM fields critical to the United States.

Schedule A Regulation from Department of Labor

Schedule A is a designation for employment-based entry to those working in fields—parameterized by the Department of Labor (DOL)—as lacking "sufficient US workers who are able, willing, qualified, and available pursuant to regulation" (US Citizenship and Immigration Services 2024a). The Executive Order of October 30 (2023) requires the Labor

Department to publish a Request for Information to identify AI and other STEM occupations as qualified for Schedule A designation.

Although very little formal research has been conducted on these pathways, in some cases descriptive data make clear that policy shifts of this sort at the agency level can matter. For example, use of the O-1A classification for experts involved in STEM activities increased by 33% in the two years following new policy guidance on how STEM PhDs can use the category (Mervis 2023).

Moreover, US Citizenship and Immigration Services (2024b) data suggest that providing policy guidance about NIW for EB2 advanced degree holders has led more immigrants to use an employment-based green card category that allows timely, more certain adjudications and that is self-petitioning, such that about 9% of petitions for advanced degree holders in STEM used NIW before the policy guidance and now about 37% of such petitions for advanced STEM degree holders utilize NIW.

- Fiscal year 2019 (last prepandemic year's data as DHS was developing NIW guidance in 2021): 5,600 NIW approvals for STEM experts out of 77,550 total EB2 petition approvals of which 59,950 in total were for professionals engaged in STEM activities.
- Fiscal year 2023 (first full year following policy announcement in January 2022): 21,240 NIW approvals for STEM experts out of 81,380 total EB2 petition approvals of which 57,150 in total were for professionals engaged in STEM activities.

To further agency efforts in this vein, the Executive Order on Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence (Executive Order of October 30, 2023) instructs departments and agencies to explore further avenues, some of which are summarized in table 1, to facilitate the attraction and retention of foreign-born STEM experts, including by notice and comment rulemaking.[3]

Actions by the executive branch thus appear—at least in the aggregate—to have the potential to generate consequential improvements in the ability of the United States to attract and retain international STEM talent. However, 85% of high-skilled immigrants working on DoD projects are naturalized citizens (Miles, Chase, and Neufeld, forthcoming), reflecting the fact that security clearances render the feeble availability of green cards a major constraint in DoD's ability to expand recruitment of the foreign-born talent already in the United States. Only the legislative branch can establish a new category of lawful permanent residents selected for their advanced STEM expertise that contributes to

critical and emerging technology fields and allocate numbers for such new green cards that then lead to naturalization eligibility.

A bipartisan group of 70 national security experts and officials made these points in a May 2023 letter (Snyder and Cai 2023) to the House Select Committee on Strategic Competition between the United States and the Chinese Communist Party imploring congressional action on international STEM talent because when America attracts the world's best and brightest many "will be working in Pentagon-identified critical technology areas." It seems the annual National Defense Authorization Act (NDAA) is a likely place to consider statutory changes targeting the relationship between STEM experts and security, as is legislation focused on industrial policy on critical industries key to international technology competition, such as CHIPS and Science legislation, as these are bipartisan efforts squarely focused on the nation's security priorities.

The animating logic tree behind this line of legislative efforts, summarized in table 2, focusing on STEM green cards, is that:

- First, technology and innovation is at the heart of strategic competition, and the United States can win the competition only if we can reliably tap into the global supply of STEM talent.
- Second, the most effective way to attract the global talent America needs is to remove green card caps for some segment of advanced STEM R&D talent most likely to make important contributions for the United States in the technology sectors that matter most to our national security.

The 117th Congress featured some of these efforts. Table 2 reflects that in summer 2022 there was an effort around adding a generous provision to the NDAA for fiscal year 2023 that would provide STEM green cards without numerical limit to certain foreign-born STEM PhDs earning doctorates from research-intensive universities in fields relevant to critical industries or critical and emerging technologies (Gilmer 2022b). The Advanced STEM Degrees NDAA amendment driven by Representative Lofgren (D-CA) was based on Section 80303 of the House-passed America COMPETES Act and garnered bipartisan support, but ultimately it was not ruled in order for a House vote (Gilmer 2022a). Similarly, Section 80303 in the House's America COMPETES Act allowed for both STEM master's and PhD graduates from research-intensive universities both in the United States and abroad to secure green card status in certain situations. Although Section 80303 passed the House in February

2022, it was not taken up in the Senate or in the conference that led to the CHIPS and Science Act enacted in August 2022 (Anderson 2022).

H.R. 7256

H.R. 7256 was a bill proposed to develop a special immigrant visa for individuals employed by a US firm or academic institution engaged in national security efforts that protect and promote the US innovation base, who conduct research funded by the DoD, or who have technical expertise in a domain pursuant to National Defense Strategy or the National Defense Science and Technology Strategy. The plan imposes a cap of 100 principals in fiscal year 2021, increasing by 100 annually until fiscal year 2025, and remains at 500 principals thereafter. There was no legislative action on the bill (H.R. 7256, 2020).

H.R. 4350 and H.R. 6395

These two amendments were proposed to the NDAA for fiscal years 2021 and 2022 and would allow the DoD to develop a competitive process to identify individuals "essential" to advancing technologies critical to national security. In practice, this would be implemented as a special immigrant visa for individuals working on university-based research funded by the DoD or individuals possessing specific scientific or technical expertise. The plan imposes a cap of 10 principals in its first fiscal year, increasing by 10 annually until its tenth fiscal year, and remains at 100 principals thereafter. Despite passing in the House, the bill was ultimately dropped in conference before the enactment of the NDAA (H.R. 6395, 2020; H.R. 4350, 2021).

H.R. 4521

Section 80303 of what became the House version of the CHIPS bill proposed to exempt foreign-born STEM master's or PhD graduates from select US and foreign higher education institutions from worldwide and per country caps. Applicants must already have an approved EB1 or EB2 petition and have graduated from a "research-intensive" institution. In addition, master's graduates must have their employer sponsor be in a critical industry. Despite passing in the House, the bill was dropped in conference before the enactment of the CHIPS and Science Act of 2022 (H.R. 4521, 2022).

Table 2
Comparison of Recent Legislative Efforts in the 116th, 117th, and 118th Congresses Targeting Foreign National Advanced STEM Degree Holders

Legislative Proposal	Which STEM Experts	Guardrails	Numbers[a]	Results
Stand-alone bill needs vehicle H.R. 7256 116th National Security Innovation Pathway Act	Employed in US industry or academia in research that would promote and protect the national security innovation base, or in basic or applied DoD-funded research in academia; or possesses expertise that will advance critical industries as identified pursuant to National Defense Strategy or the National Defense Science and Technology Strategy (NDAA19).	Knowing that NDAA21 was going to take numerous steps to reshape the defense industrial base as a national security innovation base, the National Security Innovation Pathway Act was a bipartisan effort by HASC to acknowledge that such a shift required top talent, including international STEM experts, making contributions to industrial capacity or critical industry innovation.	101(a)(27) special immigrants starting with a cap of 100 principals annually and rising by 100 each year to 500 for fifth FY and beyond, with separate exemption from per country caps.	Bipartisan bill by Representatives Langevin and Stefanik, chair and ranking member on HASC subcommittee. No action on bill as introduced.
NDAA amendment H.R. 4350 117th—Sec. 6446 H.R. 6395 116th—Sec. 281 National Security Innovation Pathway Act for essential scientists and technologists was revised to become Langevin-Stefanik 2020 Amendment to NDAA21 and Langevin 2021 Amendment to NDAA22	Contributing to the national security innovation base by working on DoD-funded basic or applied research projects at universities or possessing expertise that will advance development of critical technologies identified by DoD.	DoD to develop competitive process to identify qualifying individuals who are "essential" to advancing critical technologies or otherwise serve national security interests, and DHS to develop petitioning process.	101(a)(27) special immigrants with cap of 10 principals annually and rising to 100 after tenth FY, with separate exemption from per country caps.	Bipartisan amendment in HASC for FY21 NDAA (had to be limited to 10 principals to be budget neutral), passed the House September 2020, dropped in conference before NDAA21 enactment. Amendment for FY22 NDAA (also limited to 10 principals), passed the House July 2021, dropped in conference before NDAA22 enactment.

CHIPS Act H.R. 4521 117th—Sec. 80303 Lofgren-driven provision in the House version of the tech/semiconductor competition legislation to modify immigration law concerning international advanced STEM degree holders	STEM master's degree or PhD awarded by research universities in United States or abroad, in specified areas of study to also include medical residencies and fellowships (by CIP code).	Must have approved EB1 or EB2 petition under current law, reserved for advanced degree professionals including outstanding researchers or professors or those working in endeavors with substantial merit in the national interest. Issuing institution must offer research-intensive education as evidenced by at least $25M annual R&D investment with special provisions for MSIs or HBCUs. If STEM master's degree, must work in critical industry.	Exempt from worldwide limits and per country caps by revision to 201(b)(1).	Passed the House February 2022 as part of America COMPETES Act, dropped in conference before CHIPS and Science Act enactment in August 2022.
NDAA administration ask DoD Scientists and Experts (2022) 117th DoD's ask in 2022 for NDAA23, to secure the admission of essential scientists and other experts to enhance the technological superiority of the United States	Master's degree, PhD, professional degree, or graduate fellowship from US university that entailed research in a field important to national security, or employed or offered job in such a field, or founded a US company contributing to such a field.	DoD or other national security agencies confirm which fields, research, or contributions would advance national security.	Exempt from worldwide limits and per country caps by revision to 201(b)(1), up to cap of 200 principals annually.	Administration ask from OMB to Congress May 2022 on NDAA for FY23 after review by the interagency of DoD's proposal. Never voted on in either House or Senate.

Table 2
Continued

Legislative Proposal	Which STEM Experts	Guardrails	Numbers[a]	Results
NDAA amendment Advanced STEM Degrees (2022) 117th Lofgren amendment to include revised version of Section 80303 from America COMPETES	STEM PhD awarded by research universities in United States or abroad, in field relevant to critical industry or a critical and emerging technology, with fields list as identified by the interagency in developing general provisions for Russian scientists in the President's Emergency Supplemental Assistance to Ukraine package sent to the Hill April 2022 (Emergency Supplemental Assistance to Ukraine 2022, 33).	Must have approved EB1 or EB2 petition under current law, reserved for advanced degree professionals including outstanding researchers or professors or those working in endeavors with substantial merit in the national interest. Issuing institution must offer research-intensive education as evidenced by at least $25M annual R&D investment with special provisions for MSIs or HBCUs. Field limitation for degree and work tied to national security.	Exempt from worldwide limits and per country caps by revision to 201(b)(1).	Bipartisan amendment found not in order by House Rules Committee for floor action on NDAA for FY23 because not budget neutral (and Ways and Means rejected filing fees to cover costs). Never voted on.
Stand-alone bill needs vehicle S. 2384 118th Keep STEM Talent Act	STEM master's degree or PhD from any US university, in traditional STEM disciplines (by CIP code).	Must have approved Permanent Employment Certification from DOL (excludes EB2 working in the national interest and all EB1). Must receive salary in excess of occupational median (excludes many early career STEM experts).	Exempt from worldwide limits and per country caps by revision to 201(b)(1).	Bill has been introduced in the 116th, 117th, and 118th by Senator Durbin, with companion House bills, bipartisan in 118th with Senator Rounds. Never voted on in either House or Senate.

NDAA amendment Defense Researchers 118th Amendment adding Fortifying Our Research Through Rigorous Evaluation and Scholar Screening Act or the "FORTRESS Act" (2024)	STEM PhD or six years' employment related to a field "critical to national security," with fields listed similar to proposal on Russian scientists in the President's Emergency Supplemental Assistance to Ukraine package sent to the Hill April 2022 (Emergency Supplemental Assistance to Ukraine 2022, 33).	Must satisfy new screening and vetting requirements. Must be citizen of a FVEY, QUAD, or NATO country. Must have certification from DoD, Commerce, Energy, DNI, or NASA that employment is on a project funded or overseen by the agency or show individual's work in academia or industry is in a field critical to national security.	Up to 5,000 principals annually, without regard to existing per country caps, but no more than three-quarters from any one country.	Amendment for armed service committees markup of FY25 NDAA.

Note: Table 2 was compiled by the author, based on the legislative text sources referenced in the table. DHS = Department of Homeland Security; DNI = Director of National Intelligence; DoD = Department of Defense; DOL = Department of Labor; EB1 = Employment-Based First Preference; EB2 = Employment-Based Second Preference; FVEY = Five Eyes; FY = fiscal year; HASC = House Armed Services Committee; HBCUs = historically Black colleges and universities; MSIs = minority-serving institutions; NASA = National Aeronautics and Space Administration; NATO = North Atlantic Treaty Organization; NDAA = National Defense Authorization Act; OMB = Office of Management and Budget; QUAD = Quadrilateral Security Dialogue; STEM = science, technology, engineering, and mathematics.

[a]Spouses and minor children of the principal STEM expert are not subject to numerical or per country caps in all of these legislative proposals.

NDAA Administration Ask, DoD Scientists and Experts

This was an amendment proposed to the NDAA for fiscal year 2023, drawn from a request of the DoD to secure the admission of essential scientists and other technical experts to enhance the technological superiority of the United States. In practice, this would be implemented as a special immigrant visa for individuals working in specific fields or on research advancing national security, as determined by the DoD. The provision was never voted on in the House or Senate (DoD Scientists and Experts 2022).

NDAA Amendment, Advanced STEM Degrees

This was an amendment proposed in the House to the NDAA for 2023 that exempts select STEM PhDs from worldwide green card limits and per country caps. To qualify, applicants must already have an approved EB1 or EB2 petition, have graduated from a "research-intensive" institution (though there is no requirement that they confer their degree from a US institution of higher education), and work in a field critical to national security. Despite bipartisan support, the bill was never voted on in the House or Senate: the House Rules Committee ruled that the amendment was not budget neutral (Advanced STEM Degrees 2022).

S. 2384

This was a bill proposed to exempt STEM master's or PhD graduates from any US higher education institution from worldwide green card limits and per country caps. To qualify, graduates would need to be employed by or have an employment offer from a US employer who has completed the DOL labor certification process and be compensated a salary in excess of their occupation-level median. In addition, the bill establishes permission for F-students enrolled in a STEM program to seek legal permanent residence and still maintain F-1 student status in the United States. The bill has been introduced in the last three Congresses in both chambers but has not yet been voted on in either the House or Senate (S. 2384, 2023).

NDAA Amendment, Defense Researchers

This was an amendment proposed in the House to the NDAA for fiscal year 2025, with possible companion amendment in the Senate, that

allows up to 5,000 individuals each year who either hold STEM PhDs related to fields critical to national security or possess at least six years of experience in such fields to obtain new conditional green card status, and which explicitly anticipates eligibility for international students earning STEM degrees in the United States or experts working abroad. The STEM experts must be citizens of a Five Eyes Alliance (FVEY), Quadrilateral Security Dialogue (QUAD), or North Atlantic Treaty Organization (NATO) country and will utilize a new conditional green card classification with mandated screening and new vetting programs. Conditions to green card status are removable after satisfactory vetting and three years of R&D employment in certain fields, without tying status to a singular employer, where qualifying employment is limited to projects funded or overseen by DoD, or other agencies, or in fields critical to national security (FORTRESS Act 2024).

IV. Current Data and Research Needs

A. Measuring, and Estimating the Drivers of, Stay Rates for Foreign National STEM Advanced Degree Holders

In many policy discussions around STEM immigration, key questions are raised about numbers that no one has data on—implying that policy analysts and decision-makers in the executive and legislative branches do not have access to many of the key facts that would, ideally, form the basis for evidence-informed policy design and implementation. As a leading example, policy discussions related to providing additional green cards for foreign national STEM advanced degree holders would benefit from knowing answers to questions such as: How many immigrants with STEM PhDs became lawful permanent residents annually? Of new STEM PhDs earned in the United States, what share leave the United States versus work initially on temporary visas versus secure legal permanent residence status? Of those who leave the United States initially, what share ever return? Of those who initially work on temporary visas, what share stay and eventually transition on to have legal permanent resident status, and how long does that take? And, with regard to STEM PhDs earning their degree outside the United States, how many make their way to the United States, and how many initially come as postdoctoral fellows or through other pathways?

A natural starting point for such questions is the NSF's Survey of Earned Doctorates, which annually attempts to gather information on

the census of newly minted PhD graduates from US universities and includes some information on their postdoctoral plans, and the Survey of Doctorate Recipients, which draws its pool of potential respondents from the Survey of Earned Doctorates and attempts to follow them longitudinally. For example, Zwetsloot, Feldgoise, and Dunham (2020) use the Survey of Earned Doctorates to document that intention-to-stay rates among international PhD graduates—who account for a significant portion of STEM PhD graduates from US universities—are 70% or higher in all STEM fields and are above 85% for students from Iran, India, and China. A follow-up by Corrigan, Dunham, and Zwetsloot (2022) uses the Survey of Doctorate Recipients to document that roughly 77% of STEM PhD graduates from US universities between 2000 and 2015 were still living in the United States.

Taken at face value, these findings could be interpreted as saying that foreign national STEM PhD students trained at US universities who want to stay in the United States postgraduation largely are able to find pathways through which to do so. Of course, even if all individuals who want to stay are able to do so—eventually—that does not mean from a policy perspective that the currently existing pathways under which individuals do stay are timely or feature optimal predictability. Indeed, Olszewski et al. (2024) argue: "One of the most widely cited reasons driving foreign STEM talent to leave the United States (and discouraging it from coming) is the country's difficult-to-navigate immigration and naturalization rules governing who can come and who can stay." Moreover, data on past cohorts of foreign national STEM PhDs are not necessarily predictive of what is happening today nor what might happen in the future, given dramatic increases in visa backlogs and uncertainty about our high-skilled immigration system's adjudications both in petition adjudications and visa applications.[4]

Moreover, by construction, the Survey of Earned Doctorates and Survey of Doctorate Recipients of course focus on PhD recipients, and analogous individual-level data are not available—to the best of our knowledge—on bachelor's and master's degree graduates. Research such as Beine, Peri, and Raux (2022), which analyzes university-by-year level aggregate data on counts of international students, suggests that only around 23% of foreign nationals in US masters' programs transition into the US workforce.

An alternative starting point would be administrative data on F-1 visas supporting international students to study at US universities linked to longitudinal data from either Census or Treasury that could follow individuals

who at some point appear on F-1 visas over time. Many foreign nationals whom firms wish to hire start out on F-1 visas, and such data could provide the basis for research on how policy and nonpolicy factors might affect the stay rates of students. For example, how have policy and regulatory changes such as the H-1B cap exemption for nonprofit research organizations, changes in the time allowed for temporary employment for international students under the OPT program, and increased use of J visas for researchers changed stay rates, adjustments of status, and work behavior of students originally trained at US universities?[5]

In recent years both Census and Treasury have made tremendous progress on compiling data sets—such as the Census's Business Dynamics Statistics of Innovative Firms (BDS-IF) project (Goldschlag and Perlman 2017)—that start to lay the groundwork for tabulating these types of statistics, but they are missing one critical input, which is that they lack data on temporary visas—for example, which students are in the United States on F-1 visas, which researchers are in the United States on J-1 visas, which STEM PhDs are employed on H-1B visas. These types of data reside at agencies like US Citizenship and Immigration Services (USCIS) and the Student and Exchange Visitor Program Office (SEVP) of Immigration and Customs Enforcement, components of the DHS, and the Bureau of Consular Affairs at the US DOS. But in principle these records can be linked at the individual level with administrative data from Census or Treasury to begin to measure and study the types of questions outlined above. Importantly, such linked census records could then be made available to other researchers via the Federal Statistical Research Data Centers infrastructure (US Census Bureau 2024), which research suggests could meaningfully affect scientific progress on this topic (Nagaraj and Tranchero 2023).

B. Modeling the Expected Effects of Policy Counterfactuals

As illustrated in table 2, the handful of recent legislative proposals in this area—although similar in their broad goal of attracting and retaining foreign national STEM advanced degree holders—differ along several dimensions that may or may not be quantitatively important. Take as two examples S. 2384 (the Keep STEM Talent Act of 2023) and H.R. 4521 (the America COMPETES Act of 2022) Section 80303. S. 2384 required a job offer paying more than median wages for a given occupation and geographic area and was exclusively limited to employers with an approved labor certification. Section 80303 was limited to STEM

graduate degrees earned at universities capable of providing research-intensified training but permitted qualifying degrees from both the United States and abroad, and it included those working with extraordinary ability or in the national interest whom Congress has exempted from the labor certification. The two pieces of legislation also differed in which classes of employment-based green cards (EB1, EB2, EB3) were exempted from statutory limits.

Better understanding the expected effects of these differences in policy design would directly inform policy development efforts, but it would also inform various modeling efforts that are required of agencies across the executive and legislative branches. For example, the Congressional Budget Office (CBO)—sometimes in collaboration with the staff of the Joint Committee on Taxation (JCT)—is required to provide information to Congress, and to the public, on the expected budgetary and economic effects of such legislative efforts. When CBO modeled (CBO 2022) the budgetary effects of H.R. 4521, Section 80303, CBO analysts needed to estimate how exempting employment-based green cards from statutory limits for applicants (as well as their accompanying spouse and minor children) who have earned a doctoral or master's degree in a STEM field at a US research institution or foreign equivalent would affect the number and characteristics of foreign nationals in the United States over time (particularly over the 10-year budget window).

To provide a flavor of what type of work is required for such modeling, consider as a publicly available example the recent work of Esche, Neufeld, and Williams (2023), who developed a population modeling approach for an H.R. 4521, Section 80303-style legislative provision, which was shared with the Penn Wharton Budget Model for use in modeling the expected budgetary effects of granting green cards to immigrants with advanced STEM degrees (Elmendorf and Williams 2024; Penn Wharton 2024).

At a high level, Esche et al. (2023) attempt to articulate and (roughly) estimate every mechanism through which a policy change to employment-based green card quotas affects the number of foreign nationals in the United States and the composition of the US population by immigration status, education, country of origin, gender, and age. The starting point for their work is recognition of the fact that an increase in the number of green cards made available by law does not translate into a one-for-one increase in the number of people in the United States. Moreover, there is not a straightforward way to simply divide newly available green cards between new arrivals and people already in the United States. Instead,

behavioral responses by the foreign-born population must be accounted for, which significantly complicate this picture. For example, the availability of new green cards change expected wait times and therefore have an effect on an individual's choices between green cards and temporary visas, choices between staying in the United States versus leaving, and the choice to come to the United States at all. Furthermore, these choices can in turn have cascading effects across the immigration system. For instance, someone who chooses to apply for a green card instead of a temporary visa such as an H-1B may free up a temporary visa slot for another individual who is not eligible for the newly uncapped green card pathway. Taken together, Esche et al. (2023) attempt to catalog an exhaustive list of 16 different mechanisms by which changes to the number of employment-based green cards affects the size and composition of the US population over time.

Esche et al. (2023) then present methods to quantitatively estimate the magnitude of each of these 16 mechanisms. The methods were intentionally designed to be feasibly implemented in data sources that are currently publicly available. Esche et al. (2023) then apply the implied estimates to assess the expected population effects of an H.R. 4521, Section 80303-style legislative provision over time. For example, an increase in employment-based green cards reduces the expected wait time for individuals in the green card backlog and shifts the age composition of those receiving green cards. Combining green card backlog modeling from the Congressional Research Service (2020) and public data on the age of those in the green card backlog, Esche et al. (2023) track how the age composition changes over time as new green cards change the pace at which green cards are awarded. In addition, the backlog wait time modeling exercise identifies the necessary time shifting for when individuals change immigration status under a policy change. Estimated wait times are also combined with recent literature from Kahn and MacGarvie (2020) and Khosla (2018) on green card delays and the stay rates of international students to estimate changes in retention. Esche et al. (2023) also draw on work by Zavodny (2022), who provides tabulations of characteristics of derivative H-4 spouses who would be authorized to work in the United States, and estimates from Carr and Tienda (2013) were applied to estimate expected sponsorship patterns via family-based pathways.[6]

This population modeling by Esche et al. (2023) was shared with the Penn Wharton Budget Model, a nonpartisan, research-based initiative at the Wharton School at the University of Pennsylvania that provides

economic analysis of the budgetary impact of proposed policy changes. Penn Wharton in turn applied this work to estimate the expected budgetary effects of granting green cards to immigrants with advanced STEM degrees (Penn Wharton 2024), providing—essentially—an analogous estimate to CBO's official cost estimate of the budgetary effects of H.R. 4521, Section 80303.

Of course, many executive and legislative branch efforts other than just the CBO are required to analyze the expected effects of Section 80303-style proposals. For example, the White House also takes efforts designed to model the expected effects of such policies as an input into work across various components of the Executive Office of the President. Applied modeling work estimating the expected effects of policy counterfactuals—along the lines of the work of Esche et al. (2023)—could thus be useful to a broad set of policy analysts and federal agencies.

C. *Estimating the Economic Effects of Foreign National STEM Advanced Degree Holders to the US Economy*

Proposals to increase the number of high-skill immigrants in a country frequently tout the potential for substantial economic benefits via additional labor supply, entrepreneurship, and innovation. The academic literature suggests—in a variety of ways—that immigrants make substantial contributions across commercial, scientific, and other domains. However, the literature offers relatively limited evidence on the expected effects of specific policy change and is thus limited in its ability to inform policy development efforts in terms of guiding what types of policy changes are likely to be most effective in achieving a given policy goal.

One frequently discussed policy proposal is to guarantee legal permanent residency for foreign-born STEM PhD students, especially those earning degrees in the United States. How would such a policy affect the number and characteristics of the foreign-born present in the United States, and what would the economic effects of this type of policy change be? Economists are starting to design randomized experiments aimed at shedding light on these questions by leveraging experimental variation in "de facto" immigration policy. Their research is leveraging an unusual policy environment that has emerged due to changes in regulatory guidance around the "O-1A" visa for individuals with "extraordinary ability." As discussed in Section III, this visa category—once rarely used—now explicitly covers accomplished foreign-born STEM PhD candidates at US universities. However, the USCIS Policy Manual update that explicitly

clarified O-1A guidance has not yet been widely diffused, and take-up of O-1A visas is, not unexpectedly, low.

V. Conclusions

Economic research has the opportunity to lay the groundwork for fact-based and evidence-based policy debates over critical policy questions, such as how best to encourage innovation and economic growth. Economic researchers have made critical contributions to understanding many key aspects of the economics of immigration—such as estimating the self-selection of immigrants, the economic impacts of immigrants on natives, and analyses of the impacts of specific immigration policies such as the H-1B visa lottery. However, economists and economic research have been less attentive to the types of policy changes related to high-skilled immigration that have been pursued in recent years by the United States via executive branch and legislative policy decisions. Working on a number of high-skilled immigration policy development efforts propels the attempt of this paper to highlight areas where investments in generating additional economic data and research would be invaluable in informing more evidence-based policy discussions in the coming years.

Endnotes

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1. In the second half of his career, Feldstein focused on developing the economics of national security as an academic field of study for economists through, for example, establishing NBER's working group on the Economics of National Security.

2. As one illustration, for many years Feldstein taught a dinner seminar at Harvard on the economics of national security (Economics 2490: The Economics of National Security Seminar); the quite comprehensive data set index from that course covers essentially no topics related to innovation nor international STEM talent: https://data.nber.org/ens/feldstein/ENSA_Dataset_BlueTOC.pdf.

3. Section 5.1 of EO 14410 focuses on international STEM talent in both AI and other critical and emerging technologies (Sec. 5.1 incorporates by reference [Sec. 3(h) of the

EO] the Critical and Emerging Technologies List Update developed by the interagency through the National Science and Technology Council; National Science and Technology Council 2024) and identifies potential agency actions by DOL, DHS, and DOS.

4. On petition adjudications, this would include, for example, the Trump administration's changes at the DHS that led to high petition request for evidence rates and increased denials (National Foundation for American Policy 2019). On visa applications, this would include, for example, the Trump administration's application of its authority under Section 212(f) of the INA (Trump v Hawaii 2018) and Presidential Proclamation 10052 "Suspension of Entry of Immigrants and Nonimmigrants Who Present a Risk to the United States Labor Market During the Economic Recovery Following the 2019 Novel Coronavirus Outbreak" (Presidential Proclamation 2020).

5. As detailed in Subsection III.B, F-1 visa holders completing their degree are eligible to work in the United States for a limited time under OPT, with non-STEM graduates being eligible to work for one year and STEM graduates being eligible for up to three years.

6. Zavodny's work relates to earlier work by Brannon and McGee (Brannon & McGee 2019a, 2019b), who conducted a survey that enabled them to describe the characteristics of derivative H-4 spouses who would be authorized to work in the United States.

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