NET WORK LISER

Discussion Paper Series

IZA DP No. 18548

April 2026

Brain Freeze: How International Student Exclusion Will Shape the STEM Workforce and Economic Growth in the United States

Michael A. Clemens
George Mason University, Peterson Institute for International Economics and IZA@LISER

Jeremy Neufeld
Institute for Progress

Amy M. Nice
Institute for Progress

IZA DP No. 18548 April 2026

Brain Freeze: How International Student Exclusion Will Shape the STEM Workforce and Economic Growth in the United States*

Abstract

This paper examines how proposed U.S. restrictions on international students would affect the nation's STEM workforce and long-run economic growth. Focusing on the most common pipeline from U.S. universities to the labor market, we show that international education is the principal mechanism by which the United States recruits and retains high-skill STEM talent. We present survey evidence suggesting that proposed policy changes will deter substantial numbers of international students from studying in the United States and remaining in its workforce after graduation. We then estimate the effects of plausible policy-induced declines in the number of foreign STEM graduates entering the U.S. workforce. A sustained one-third reduction would shrink the high-skill STEM workforce by about 6 percent overall, potentially by more than 11 percent at the Ph.D. level, and would lead to long-run GDP losses of $240 billion to $481 billion annually. These losses are unlikely to be offset by U.S.-born workers or foreign-trained workers abroad. Drawing on evidence on innovation, entrepreneurship, and spillovers, we conclude that restricting this talent pipeline would weaken innovative capacity and long-run productivity in the U.S. economy.

JEL classification

F22, J61, O33

Keywords

immigration, productivity, skill, students, universities, research, innovation, patents, productivity, macroeconomic, restrictions, barriers

Corresponding author

Michael A. Clemens
mcleme@gmu.edu

* This paper was commissioned by the US National Academies of Science, Engineering and Medicine (NASEM) for the "Reimagining STEMM Graduate Education and Postdoctoral Career Development" Summit. Opinions and statements included in the paper are solely those of the individual authors, and are not necessarily adopted, endorsed, or verified as accurate by the planning committee or NASEM. Clemens acknowledges support from the Peterson Institute for International Economics and Coefficient Giving. This analysis was originally posted by the National Academies at:
https://nap.nationalacademies.org/resource/29283/BrainFreeze_Working_Paper_Clemens-Neufeld-Nice.pdf

I. INTRODUCTION

America's enduring advantage has been its ability to recruit and educate top talent from around the globe (Bloom et al. 2019; Glennon 2024; Ganguli and MacGarvie 2025). Yet this advantage, built over decades of scientific leadership and institutional strength, now faces unprecedented challenges. Sustaining America's technological and economic leadership requires recognizing the value of international talent, the central role of U.S. universities in training this talent, particularly in STEM fields, and the growing risks to this system.

The federal government is actively pursuing policies to reduce the number of international students at U.S. universities and to restrict the share of those who remain in the workforce after graduation. For example, the administration required Columbia University to decrease its reliance on international student enrollment as a condition for receiving federal research funding[1] and requested other universities to sign a compact including caps on international undergraduate enrollment and enrollment from any one country as a condition for preferential access to funding.[2] Likewise, the director of the agency overseeing immigration adjudications stated that policy should make it "abundantly difficult" for foreign students to expect to remain in the United States beyond their visa period.[3]

At the time of writing, the administration has announced several forthcoming measures that will directly affect international students, scholars, and researchers on U.S. campuses. These include:

- **Terminating Optional Practical Training (OPT):** Eliminating the long-standing program that provides post-graduation work authorization and serves as a bridge into the U.S. workforce.[4]
- **Ending duration of status (D/S):** Replacing admission valid through program completion with a fixed four-year period, requiring discretionary extensions mid-program or at the point of post-graduation employment.[5]
- **Seniority-based H-1B allocations:** Prioritizing later-career workers over recent graduates, reversing a long-established practice of accessibility for early-career professionals.[6]

The central questions that we seek to answer are: how many international students will be deterred or blocked from entering the U.S. workforce by these changes? And how will resulting losses affect the U.S. STEM workforce and the resulting productivity of the American economy?

This paper examines two plausible scenarios in which the number of foreign STEM graduates from U.S. universities entering the U.S. workforce falls and evaluates the likely consequences for the high-skill workforce and economic growth. The analysis draws on multiple data sources—including census records, surveys of current and prospective international students, and administrative data from the Department of

---

[1] Office of the President, "Our Resolution With the Federal Government", New York: Columbia University, July 20, 2025, paragraph 22, page 9.
[2] Natalie Andrews and Douglas Belkin, "White House Asks Colleges to Sign Sweeping Agreement to Get Funding Advantage," *Wall Street Journal*, October 1, 2025.
[3] Director of US Citizenship and Immigration Services Joseph B. Edlow, quoted by Neil Munro, "Citizenship Chief Says Federal Work Permits for Foreign Grads Are 'Depressing Wages'", *Breitbart*, August 19, 2025.
[4] USCIS Director Joseph Edlow stated that he will eliminate OPT at his Senate confirmation hearing on May 26, 2025: Stuart Anderson, "New Immigration Service Director May Pursue An Anti-Immigration Agenda", Forbes, August 4, 2025. Full video at https://www.judiciary.senate.gov/committee-activity/hearings/05/21/2025/nominations.
[5] 90 Fed. Reg. 42070 (Aug. 28, 2025).
[6] 90 Fed. Rev. 45986 (Sep. 24, 2025).

Homeland Security—and focuses specifically on students earning degrees in science, technology, engineering, and mathematics.[7]

First, we conservatively estimate the combined effect of the proposed policy changes will result in a sustained one-third reduction in the annual flow of foreign STEM graduates through the labor force. We estimate this reduction would shrink the U.S. high-skill STEM workforce by 6.2 percent overall and by 11.4 percent at the Ph.D. level. Based on the best available economic research, such a contraction would lower the annual productivity growth of the United States by 3–6 percent (0.08–0.16 percentage points of growth per year), which would translate to yearly GDP losses of $240-481 billion after a decade. This estimate conservatively reflects long-term losses from ongoing deterrence caused by the suite of new restrictions. It separately represents an approximate but conservative *mechanical* effect on the number of high-skill foreign STEM workers in the U.S. economy due to rescission of OPT—their principal bridge between U.S. universities and the U.S. labor market—even in a scenario of constant enrollment of international students.

In **Section II**, we describe the policy history of the programs that the administration is proposing to change. In **Section III**, we explain how the country's STEM workforce has been augmented by recruiting international students from U.S. institutions after graduation. **Section IV** describes and quantifies how international graduates transition between different immigration statuses after graduation, including through programs like OPT, J-1, H-1B, O-1A, and employment-based immigrant categories. **Section V** quantifies the effects of a reduction in international students on the STEM workforce. **Section VI** considers whether other STEM workers (foreign-trained or domestic) could mitigate the effects discussed in section V. **Section VII** describes predicted effects on the STEM workforce and the potential implications for the trajectory of U.S. productivity and growth, revealing major consequences for the U.S. economy.

II. POLICY CONTEXT

International students earning degrees in the United States are a critical input to the nation's STEM workforce and economy. Many international students come to the United States to attend universities and enter the U.S. labor force in the short term but remain in the country in the long term. This is especially true for international students pursuing STEM degrees. The administrative data show that 54 percent of F-1 graduates get OPT, with most of the remaining 46 percent returning home after earning their degree. The initial retention numbers are higher among Ph.D.s (67 percent) specifically and STEM grads generally, with 77.8 percent of international students earning STEM degrees immediately entering the workforce upon completing their degree, through what we call in this paper the 'front door' talent pipeline (63.7 percent on OPT, 13.6 percent changing status directly to H-1B from F-1 without OPT, 0.5 percent changing status to another nonimmigrant work visa category without OPT). The front door talent pipeline is comprised of stages, including: F-1 student enrollment, transitions from F-1 status to OPT work authorization (if applicable), and transitions from F-1 student status (whether on OPT or not) to H-1Bs.
Ending Duration of Status, ending OPT, and prioritizing seniority in H-1B issuance would strike a blow at all three components.

[7] We follow the National Science Foundation in defining STEM herein as science and engineering ('S&E') disciplines, excluding those related to health ('S&E-related').

Duration of Status

Duration of status was introduced in 1978 to allow international students the ability to be admitted to the U.S. for however long it took them to complete their degree and to engage in post-graduation employment experience related to their field of study**.** As explained by the Immigration and Naturalization Service (INS) then:

"The proposed amendments will eliminate the need for nonimmigrant students to apply for extensions of stay and summer employment, and will eliminate the need for the Service to adjudicate the large numbers of applications now required under existing regulations. Under the proposed rule, immigration controls on students will be similar to those for foreign diplomats. The Department of State now informs the Service when a diplomat is no longer accredited, and the proposed rule will require Foreign Student Advisors to advise the Service when students are no longer enrolled in school, or when significant changes in their status occur. These amendments are needed to facilitate the admission of nonimmigrant students and intended to reduce the Service adjudications workload, while providing adequate immigration controls on persons here on student visas."[8]

Soon after its initial introduction, during the Iranian hostage crisis, duration of status admission was supplemented by an Iranian Student Registration Program which required additional close government monitoring and compliance obligations for Iranian students but nobody else, followed by a period when INS experimented with various changes and conditions to duration of status, including a two-year testing of whether the agency should return to fixed periods of admission. Ultimately, INS rejected fixed periods of admission. Since October 1991, international students have relied on the expectation that they can maintain status for the duration of their educational program plus any period of post-completion OPT. DHS has published a proposed new regulation eliminating Duration of Status (D/S) admissions, resulting in a situation in which international students no longer have relative certainty that their period of stay will cover their completion of a U.S. degree and training programs.[9]

OPT rescission

In August 1947,[10] the Department of Justice, then responsible for immigration through its component agency INS, promulgated a regulation permitting "employment for practical training" for international students after completion of the student's regular course of study. For over 78 years since, a program allowing employment authorization for international students after they have completed their degrees has continued. First referred to as Optional Practical Training in 1992, OPT took its modern form then, under President George H. W. Bush, with an initial limit of 12 months on post-completion employment.[11] The extension of F-1 nonimmigrant student status that OPT allows is now governed by regulations enforced through the Department of Homeland Security (DHS). In 2008, DHS announced a now invalid rule which made a 17-month STEM OPT extension available for graduates of STEM degree programs. Following an August 2015 court decision, a new rule replaced the 2008 regulation, which allowed for a 24-month "STEM OPT extension,"[12] which currently governs post-graduation employment authorization for STEM grads. This allows international students earning U.S. degrees in designated STEM degree programs[13]

---

[8] 43 Fed. Reg. 32306 (July 28, 1978).
[9] 90 Fed. Reg. 42070 (August 28, 2025).
[10] 12 Fed. Reg. 5355 (August 7, 1947).
[11] 57 Fed. Red. 31954 (July 20, 1992).
[12] 81 Fed. Reg. 13040 (March 11, 2016).
[13] DHS STEM Designated Degree Program List (last updated July 22, 2024).

whose employers complete a STEM OPT attestation,[14] to access a 24-month STEM OPT extension after the 12-month post-completion OPT available to all F-1 visa holders. DHS has announced that it will develop a regulation to restrict post-completion OPT.[15]

H-1B restrictions

Established in the 1952 rewrite of the nation's immigration laws, for the last 73 years, the H-1 visa classification has allowed U.S. employers to hire professionals born outside the US. Since 1990, this category has been subject to numerical limits and a labor condition application, and the category has been designated as the H-1B visa. U.S. Citizenship and Immigration Services (USCIS) and its predecessor agencies have consistently recognized that this category is intended for professionals at all levels of experience, including early career professionals. INS explained in a January 1990 rulemaking that the inclusion of entry-level members of a profession had been well-established since before 1970 and "that a Congressional amendment to the statute would be required to change the current interpretation after such a long time."[16] When Congress considered revisions to H-1 in the bill that became IMMACT90 later that year, the House Judiciary Committee reported that "the bill recognizes that certain entry-level workers with highly specialized knowledge are needed in the United States and that sufficient U.S. workers are sometimes not available."[17] The 1990 overhaul of the legal immigration system retained the ability of early career professionals to utilize the newly delineated H-1B visa classification.

Yet, DHS has proposed a new regulation to reorder H-1B access by seniority, disadvantaging early career professionals and recent international student graduates. The Trump administration has announced a presidential proclamation claiming authority to impose a $100,000 fee at the time of adjudication of certain H-1B petitions.[18]

The connective tissue between F-1 student enrollment and the workforce is duration of status admission, access to OPT, and access by F-1s to H-1B status.

III. FOREIGN STEM TALENT IN THE U.S. WORKFORCE AND UNIVERSITIES

America's visas for foreign-born skilled workers mainly serve as a retention mechanism rather than a recruitment engine. Programs like H-1Bs and employment-based green cards predominantly serve those already within our borders. As our capacity to identify and attract fresh international talent remains fairly limited to institutions of higher education, universities have become our de facto talent pipeline.
International students, visiting scholars, and research fellows represent the primary pathways through which high-skilled individuals first arrive in America. As one National Academies committee chair aptly observed in 2024, "The United States has a talent [recruitment] program. It's called graduate school."[19]

International education is a major U.S. export industry, contributing $54.8 billion to the U.S. economy in 2024.[20] But the most important contribution of international students, scholars, and researchers who are

---

[14] I-983 Training Plan for STEM OPT Students.
[15] Spring 2025 Unified Agenda for DHS includes a new rule governing practical training (September 2025).
[16] 55 Fed. Reg. 2606 at 2608-2609 (January 26, 1990).
[17] H.R. Rep. 101-723 at p. 6747 (September 19, 1990).
[18] 90 Fed. Reg. 45986 (September 24, 2025) and Restriction on Entry of Certain Nonimmigrant Workers (September 19, 2025).
[19] Karen Fischer, "To remain scientifically competitive, the US must take a coordinated national approach", *Latitudes* blog at the *Chronicle of Higher Education*, September 4, 2024.
[20] Bureau of Economic Analysis, "Table 2.1. US Trade in Services, by Type of Service", US Dept. of Commerce. July 3, 2025 release.

attracted to U.S. college campuses is the way in which they power the engine of American innovation after entering the workforce. Immigrants founded 44 percent of all "unicorn" billion-dollar startup companies from 1997 to 2019,[21] and immigrants or their children founded 46 percent of the "Fortune 500" largest firms in America.[22] Of the immigrants who founded high-potential startups backed by venture capital, 75 percent came to the United States as international students—not on work visas, not on family visas, not by any other channel (Amornsiripanitch et al. 2023). International students who remain in the United States after their education are, collectively and disproportionately, a force for economic growth. Of the top AI firms in America that have received the most venture capital support, 70 percent have a co-founder that is an immigrant who first came to the United States as an international student at a U.S. university.[23]

The value proposition extends beyond individual achievements. International graduate students are a major source of talent, enabling American universities to maintain world-class research programs and American companies to develop and commercialize ideas. Immigrant inventors are responsible for 32 percent of aggregate innovation in the United States, in part by raising the productivity levels of their non-immigrant colleagues and collaborators, enabling domestic STEM professionals to innovate at higher rates (Jaravel et al. 2018; Bernstein et al. 2022).

The U.S. is more reliant on international talent in technical STEM fields and at higher levels of education. The foreign-born share of the U.S. population is approximately 16 percent, but foreign-born workers make up 30.0 percent of today's employed high-skill STEM workforce—that is, workers in Census-defined STEM occupations who hold a bachelor's degree or above. Growth in foreign-born workers accounts for 36.2 percent of all growth in the employed high-skill STEM workforce since the year 2000 (**Figure 1a**).[24] The figure shows a snapshot of the population, measured at a specific time point each year—that is, a stock rather than a flow.

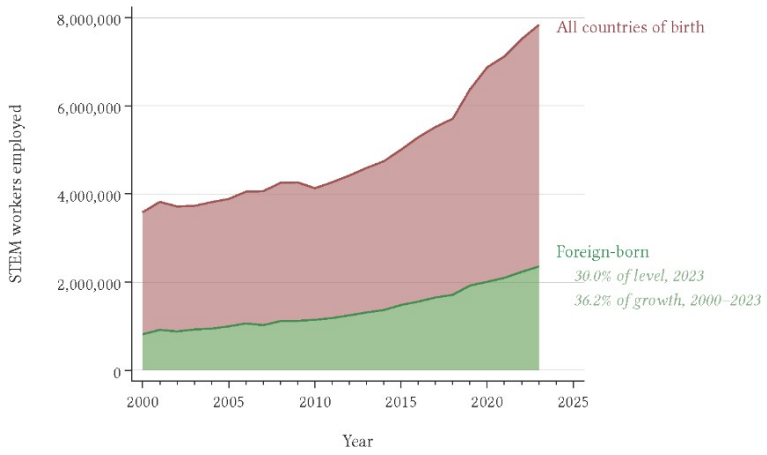
The role of immigrants is even more central at higher levels of skill. Foreign-born workers make up 42.1 percent of today's employed STEM workers whose highest degree is a master's. Foreign-born workers make up 50 percent of all growth in employed STEM workers whose highest degree is a master's since the year 2000 (**Figure 1b**). At the doctoral level of training, foreign-born workers make up 49.2 percent of today's employed STEM workers with a Ph.D.. They constitute 62.2 percent of all growth in employed STEM workers with a Ph.D. since the year 2000 (**Figure 1c**).

This prevalence of immigrants in the high-skill STEM workforce has occurred alongside high rates of international student graduation from STEM programs at U.S. universities. **Figure 2** shows the annual

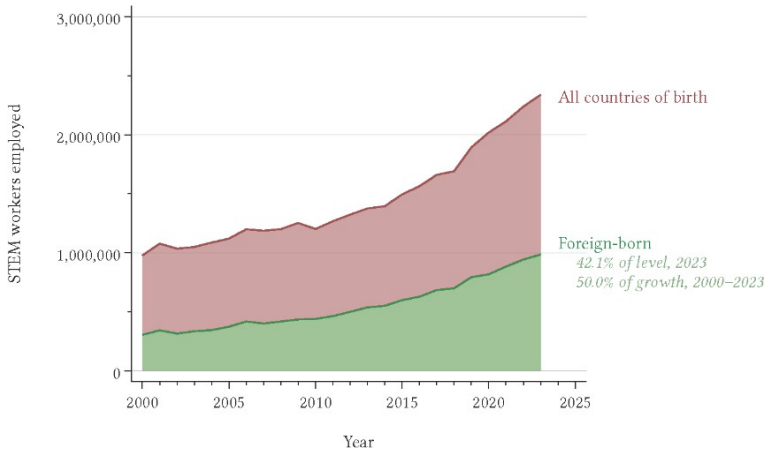
---

[21] Ilya Strebulaev, "The Immigrant Edge: How Foreign-Born Entrepreneurs Drive America's Unicorn Boom", *Crunchbase News*, May 13, 2025. Data from the Stanford University Venture Capital Initiative.
[22] American Immigration Council, "New American Fortune 500 in 2024", Sept. 9, 2024.
[23] Jeremy Neufeld and Lindsay Milliken, "Most of America's Top AI Companies Were Founded by Immigrants," Institute for Progress, April 16, 2025.
[24] Data from the American Community Survey 1-year public-use files (Ruggles et al. 2025). Includes only workers aged 18–65, who have completed a bachelor's degree or higher and are currently employed in an occupation coded as a Science and Engineering (S&E) occupation by NSF (2024, Table SLBR-1). This definition does not include medical fields, which the National Science Foundation categorizes not as S&E occupations but as "S&E related." At the time of writing, the 2023 microdata are the most recent available.

(a) All high-skill STEM



(b) Highest degree master's



(c) Highest degree Ph.D.

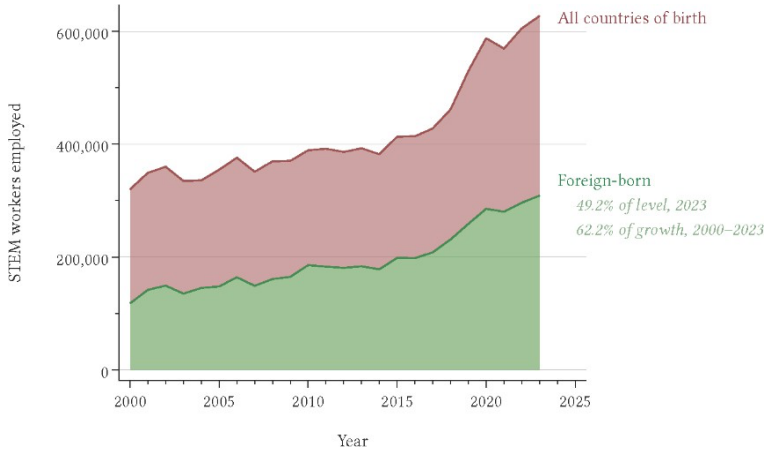
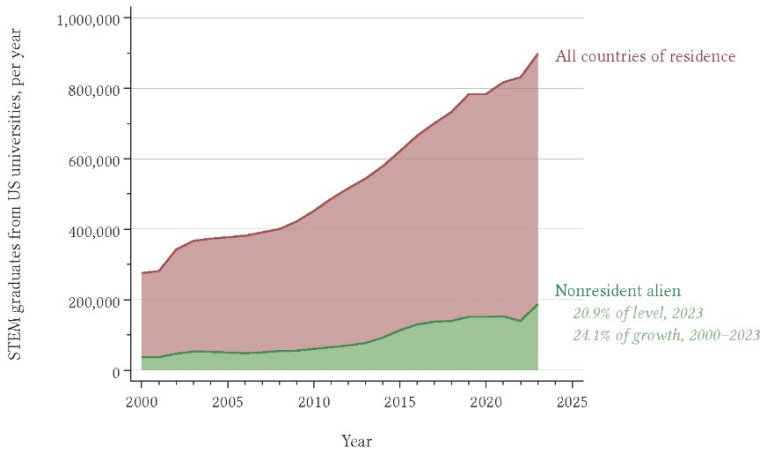
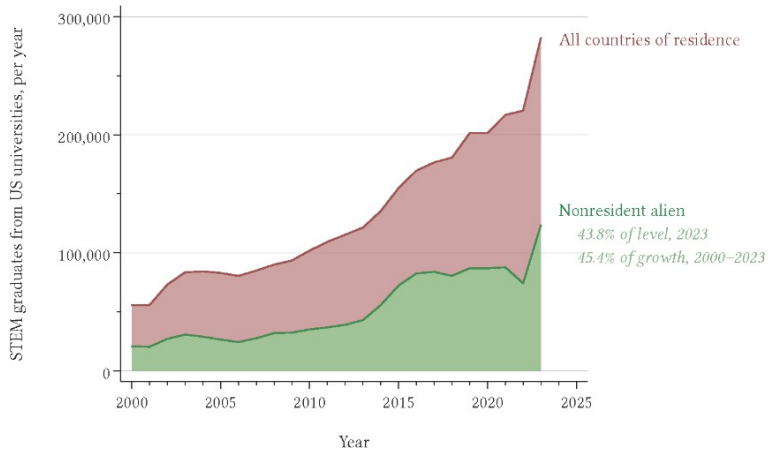


Figure 1: Immigrant prevalence among employed U.S. high-skill STEM workers (stock), 2000–2023

(a) All university degree completions



(b) Master's degree completions



(c) Ph.D. degree completions

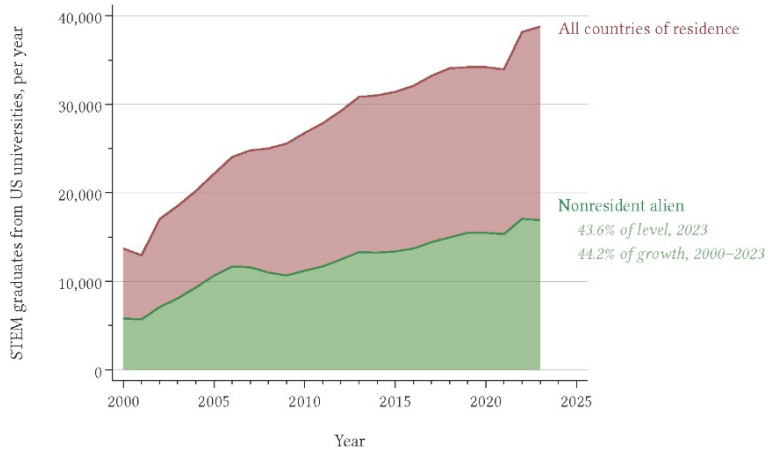


Figure 2: Immigrant fraction of new STEM graduates from U.S. universities (flow), 2000–2023

flow of new graduates from U.S. universities in STEM fields.[25] In the most recent cohort of students in STEM fields completing any higher-education degree, 20.9 percent of graduates are nonresident aliens—people who are neither citizens nor permanent residents of the United States,[26] including people on student or training visas. Nonresident aliens make up 24.1 percent of the growth in the flow of STEM graduates, at all degree levels, since the year 2000 (**Figure 2a**).

Again, the role of international students is even more central at higher levels of education. Among students completing master's degrees in STEM disciplines, 43.8 percent are nonresident aliens. Those international students make up 45.4 percent of the rise in the annual flow of new STEM master's graduates since the year 2000 (**Figure 2b**). These numbers are similar at the Ph.D. level. 43.6 percent of recent new Ph.D. graduates in STEM are nonresident aliens, and those international students make up
44.2 percent of the rise in the annual flow of new STEM Ph.D. graduates at U.S. universities since the year 2000 (**Figure 2c**). At many top research universities, international students now constitute the majority of graduate students in computer science, electrical engineering, and other crucial fields for American competitiveness.

This phenomenon is not new. Compare the *level (flow)* of international student prevalence among STEM graduates to the *growth*. For example, the current *flow* and *growth* of Ph.D. STEM graduates over the past quarter century have both been approximately 44 percent international students (**Figure 2c**). This implies striking stability in the reliance of U.S. higher education in STEM on foreign talent over the past generation. The economic importance and public salience of high-skill STEM workers have risen in recent years, as the demand for their work has boomed. Still, the United States's relative reliance on global talent for new graduates in those fields has been high for decades.

What, then, would be the effect of slashing international student graduates in STEM (**Figure 2**) on the U.S. high-skill STEM workforce (**Figure 1**)? The effect is not straightforward. Many international graduates from U.S. universities do not remain in the country in the long term or even enter the U.S. labor force in the short term. That population would not be 'lost' to the workforce even if they had never come to study in the United States. To quantitatively estimate the effects of reductions in international graduates on the U.S. high-skill STEM workforce, we must estimate the U.S. retention rate of different types of international graduates.

IV. INTERNATIONAL STUDENT TRANSITION FROM UNIVERSITY TO WORKFORCE

Understanding America's high-skill immigration system requires viewing it as a complex pipeline with multiple entry points, bottlenecks, and exit ramps. This pipeline operates on a logic of temporary-to-permanent progression (Bound et al. 2021; Glennon 2024; Ganguli, and MacGarvie 2025).

The employment-based green card system functions fundamentally differently than many assume. Rather than serving as America's primary tool for attracting new international talent, these permanent residency

---

[25] Completion data for 2000–2022 are from the Integrated Postsecondary Education Data System (IPEDS) from the National Center for Education Statistics (NCES) at the US Dept. of Education, via the Urban Institute *Education Data Portal*, accessed July 16, 2025. Data for 2023 have not been incorporated into the Urban Institute portal and are thus taken directly from: National Center for Education Statistics, "IPEDS Data Center," US Dept. of Education, accessed June 20, 2025. STEM degrees are defined using the US Department of Homeland Security DHS *STEM Designated Degree Program List*, which was issued in 2016, 2020, 2022, and 2023, for the relevant year. That is, 2023 graduates are classified using the 2023 list, 2022 graduates using the 2022 list, 2020–2021 graduates using the 2020 list, and graduates before 2020 using the 2016 list (the first official list issued by DHS).

[26] We refer to these noncitizens as "aliens" because that is the term used throughout the administrative data.

pathways overwhelmingly benefit individuals who have already established themselves within U.S. borders. The vast majority of employment-based green cards go to people already working in the United States on temporary visas, particularly H-1B holders, through a process called "adjustment of status."

This distinction is crucial for understanding the immigration pipeline's architecture. While permanent residency offers invaluable benefits—such as the freedom to change employers, launch businesses, enjoy greater career flexibility, and ultimately become a naturalized U.S. citizen—it represents the culmination of an immigration journey. The beginning of that journey is often arrival on a student visa. The green card is the mechanism that transforms temporary workers into permanent residents, preventing brain drain rather than initiating "brain gain."

If green cards primarily serve retention, then recruitment happens elsewhere—specifically through the complex ecosystem of non-immigrant visa programs. These temporary statuses form the gateway through which high-skilled workers enter the United States, albeit with significant limitations that make eventual permanent residency essential for long-term retention.

The U.S. high-skilled immigration system resembles a massive funnel with multiple entry points but increasingly narrow passages as individuals progress toward permanent residency.

- **The F-1 student visa** represents the widest opening in this funnel, with recent admissions of approximately 350,000 to 400,000 new, first-time active international students annually, without numerical caps. This program does more than educate—it serves as America's primary talent scouting mechanism.
- **The F-1 Optional Practical Training (OPT) program** allows F-1 graduates to gain on-the-job experience as part of their educational program before leaving the country or securing another immigration status. F-1 graduates can get one year of post-graduation employment authorization, with STEM graduates enjoying up to three years of employment authorization. This bridge period allows employers to evaluate talent and allows workers to establish themselves professionally before transitioning to more permanent arrangements. This program is a crucial pipeline in transitioning international graduates into the U.S. workforce.
- **The H-1B Visa** stands as the flagship high-skilled work visa, though its dual role often goes unrecognized. A significant share of H-1B visas is used to retain international talent that is already in the country—particularly recent graduates transitioning from student status. The private sector cap of 85,000 visas (with 20,000 reserved for U.S. advanced degree holders) creates an annual lottery system where demand far exceeds supply. Universities, government research entities (like the national labs), and non-profit research organizations enjoy exemptions from these caps, reflecting policy priorities around academic and research talent.
- **The J-1 Exchange Program** occupies a unique niche, bringing in about 100,000 high-skilled participants annually across various categories. The single largest group of J-1 participants is foreign students in degree-granting programs abroad who come to the United States on a summer work and travel program (about one-third of all new, first-time active J-1s annually), with most others being young people who come as au pairs, camp counsellors, high-school students, interns, and the like. J-1 program participants, however, are also teachers, professors, and researchers. The program is vital in academic research, with nearly all postdoctoral researchers entering through this pathway. Most J-1 participants have historically been prevented from remaining in the U.S. long term due to restrictions on this exchange visitor classification.

- **The O-1A Visa** serves as the elite pathway, reserved for those demonstrating extraordinary ability in their fields. About 10,000 are issued annually.
- **Lawful permanent residency (green card)** affords the right to stay in the United States permanently, enjoying free movement, authorized employment, changes of employer, and retirement without sacrificing status. Only approximately 120,120 employment-based (EB) green cards are issued each year, based on selection tied to education, experience, and future employment.[27] Because spouses and minor children of the so-called "principal" beneficiaries also count towards the cap, less than half of the 120,120 green cards are allocated to selected high-skilled principals. The United States awards approximately 40,000 green cards every year to each of the three skill-based categories (EB-1, EB-2, and EB-3).

The talent pipeline structure creates two critical choke points that fundamentally shape the experience of international students transitioning into the U.S. workforce.

The first bottleneck is transitioning to a non-immigrant work visa. Many international graduates face their first major hurdle when attempting to secure H-1B or other work authorization as their student status expires. Statutory quotas for cap-subject employers (like for-profit companies) mean talented individuals often must leave despite eligibility, a willing employer, and strong qualifications.

The second bottleneck is imposed by green card caps. The most severe constraint occurs at the pipeline's end, where annual green card limits create massive backlogs. The mismatch between the number of temporary visa holders and available green cards means that many high-skilled workers spend years—sometimes decades—in temporary status, despite having obtained petitions confirming eligibility for classification as a lawful permanent resident. This uncertainty affects career decisions, family planning, and entrepreneurial ambitions.

Measuring inflows and transition rates

To understand how policy changes and changes in enrollment patterns would affect the high-skilled workforce in the United States, we need to estimate both the **inflows** for the different immigration statuses and the **transition rates**. We define inflows as the total number of new people entering a program within a given year; that is, the sum of the new people entering the United States from abroad and the people transitioning from another status. We define a long-term transition rate *between* any two immigration statuses as the proportion of members of the new cohort in one program who have directly transitioned into and acquired status in the second program, regardless of how long that transition takes. For example, we take the F-1 OPT to H-1B transition rate to be the share of F-1 OPT participants who get an H-1B directly following F-1 OPT. The F-1 OPT to EB transition rate is the share of OPT participants who get employment-based green cards directly after OPT; it does not count OPT participants who get an EB after first transitioning onto an H-1B (or obtain green card status through marriage). We define the long-term retention rate for a program as the share of a cohort in one program who have obtained EB permanent residency status at any point, regardless of whether it is their *next* status. We inform both inflows and transition rates estimates with anonymized, full-universe administrative data from the Student

[27] There are also 19,880 green cards that are considered part of the "employment-based" system (EB-4 and EB-5) simply because they are not family-sponsored green cards. These go to investors, religious workers, unaccompanied juveniles, former NATO employees, and various others.

and Exchange Visitor Information System (SEVIS) of the U.S. Dept. of Homeland Security, obtained by a request under the Freedom of Information Act.[28]

Inflows

Estimates for inflows are shown in **Table 1**. Using microdata from SEVIS, we estimated 226,000 new F-1 students graduate each year;[29] of those, 104,000 graduate in STEM fields and 23,000 graduate with Ph.D.s. Similarly, for high-skilled J-1 new arrivals, we used SEVIS data on new J-1 visitors by exchange category. From 2014 to 2023, approximately 100,000 high-skilled J-1 visitors entered the United States each year.[30] We also have microdata on degree fields for categories representing over half of the 100,000 high-skilled J-1 visitors. From this, we estimated that the share of new high-skilled J-1s who have STEM degrees is 31 percent, suggesting an inflow of 31,000 high-skilled J-1 workers in STEM fields. Assuming that Ph.D.s use the research scholar, specialist, and student doctorate categories, we find that there are 29,000 newly arriving Ph.D.s each year on the J-1 program.

We estimated H-1B new arrivals using information from DHS's H-1B Characteristics Reports, which specify whether initial H-1Bs request changes of status or consular processing.[31] Given that some international scholars with status still pursue consular processing (we assume it is 6 percent of total consular processing), we estimate 61,000 new H-1B arrivals each year. Of those, we estimate that 79 percent, or 48,000, are for STEM workers (inferred from STEM occupations) and 14 percent or 9,000 hold Ph.D.s.

Finally, we estimated aggregate EB-1, EB-2, and EB-3 new arrivals using data from DHS's statistical yearbook.[32] This suggests 15,000 EB green cards each year go to new arrivals, of whom we estimate only 10,000 are STEM and 1,000 hold Ph.D.s. Altogether, this suggests that the U.S. admits about 400,000 high-skilled visitors each year. However, as we will see, it only retains a fraction of them.

Table 1: Estimates of new arrivals from abroad

	Total	STEM	Ph.D.
F-1	226,000	104,000	23,000
J-1	100,000	31,000	29,000
H-1B	61,000	48,000	9,000
EB-1, EB-2, and EB-3	15,000	10,000	1,000

[28] FOIA request fulfilled in December 2023 covering calendar years 2004 through mid-2023, ICE request 2023-ICFO-43657.
[29] We could count new enrollments to capture when people first arrive, but we prefer to count them when they graduate because it simplifies our analysis, allowing us not to factor in variation in program lengths, lags between enrollment and graduation, and attrition of students. It does not materially change our results.
[30] Clemens, Neufeld, and Nice, Expelling Excellence: Exchange Visitor Restrictions on High-Skill Migrants in the United States, Policy Paper No. 214, IZA Institute of Labor Economics, September 2024.
[31] Dept. of Homeland Security, *Characteristics of H-1B Specialty Occupation Workers* (annual), various years. For example, the FY2023 report is available at: https://www.uscis.gov/sites/default/files/document/reports/OLA_Signed_H-1B_Characteristics_Congressional_Report_FY2023.pdf [32] Office of Homeland Security Statistics, *Yearbook of Immigration Statistics* (annual), various years.

Transition Rates

For F-1 international students, we present estimates of the principal channels for long-term retention—otherwise known as the 'front door'—in **Table 2**.

The first major transition we consider is F-1 to F-1 OPT (see the *short-term* section of **Table 2**). OPT represents the first opportunity for post-graduation work authorization and represents a major pipeline for international graduates into the U.S. workforce. SEVIS data reports directly that over the last five years of available data (2018–2022), 54 percent of F-1 graduates were approved for OPT. That number is higher among STEM graduates (64 percent) and among Ph.D.s (67 percent).

The next major transition is F-1 to H-1B (see *medium-term* section of **Table 2**). SEVIS data suggest that about 9 percent of F-1 graduates get an H-1B immediately, without OPT percent. That percentage is higher still for STEM graduates (13.6 percent) and Ph.D. holders (10.8 percent). However, transitioning to an H-1B from OPT is much more common. SEVIS data show that 29 percent of OPT participants in all fields get an H-1B (15.4 percent of all graduates). Among Ph.D.s, the share is 41 percent (27.8 percent of all graduates). Given STEM OPT's longer duration, it is not surprising that a greater share of STEM grads (52 percent of OPT participants and 33.4 percent of all graduates) change status to an H-1B after OPT.[33]

The final major transition we consider is H-1B to EB (see *long-term* section of **Table 2**). H-1Bs are indefinitely renewable for those with an approved EB petition, so even someone who waits decades may eventually get an EB. This means that there is likely a significant difference between short-term and long-term transition rates, as well as differences dependent on the country of origin. We take the transition rate of H-1B to EB-2 (non-National Interest Waiver) and EB-3 from FY 2024 Permanent Employment Certification (PERM) data,[34] and apply this to *principal* visa recipients (excluding spouses and dependents). We adjust the H-1B to EB-1 rates by *excluding* intracompany transfers and principal visa recipients shifting status to EB-2 or EB-3. This calculation suggests that about 41 percent of H-1Bs and
4.8 percent of other nonimmigrant work visas (E-3, H-1B1, O-1, and TN) transition to EB-1,2,3.[35]

For long-term retention on H-1B visas, we compare the number of approved H-1B petitions for continuing employment (extensions) to the number of approved petitions for initial employment three years prior.[36] The number of petitions for continuing employment includes standard continuation (first-time renewal of the H-1B), extended renewals for those who have already renewed once, and (extended) renewals for those who have an approved petition for an EB green card but are waiting for an EB green card to

---

[33] These rates are directly observed as changes of status in SEVIS. Given that some F-1s secure an H-1B through consular processing and without changing status, the true transition rates are likely to be roughly 9 percent higher than the change-of-status rates.

[34] Dept. of Labor Office of Foreign Labor Certification, *Performance Data*, various years. 'PERM' is a shorthand for 'Permanent Labor Certification', an approval by the Dept. of Labor required before employers can petition for certain kinds of employment-based immigrant visas (green cards).

[35] We first count the total adjustments of status to EB green card each year, omitting adjustments to EB-1 by multinational executives and managers who are overwhelmingly adjusting from L-1 visas not typically held by recent graduates of US universities (Mukhopadhyay and Oxborrow 2012, 222). We allocated the remaining adjustments to non-immigrant work visas in the same proportion as the adjustments recorded publicly in the PERM data, which are available for most of the remaining EB adjustments (all EB-3 adjustments and EB-2 adjustments where the principal has not obtained a National Interest Waiver). We then note that the year of adjustment in the PERM data, compared to the year of first arrival in the United States, implies that a typical adjuster on an H-1B visa is adjusting after roughly six years on an H-1B visa. We then compare, for example, the implied number of H-1B-to-EB adjustments against the number of H-1B visa petition approvals for initial employment from six years prior. This gives the H-1B-to-EB transition rate in the figure. Note that it does not include workers who extend their stay on an H-1B visa past six years with an approved immigrant visa petition, many of whom may later adjust to an EB green card.

[36] The number of H-1B petitions for initial employment is primarily governed by statutory caps, so it is relatively stable from year to year. Since the vast majority of H-1B visas for initial employment are extended from the original three years for an additional three years, the number of approved continuing-employment petitions in a given year should be roughly equal to or slightly less than the number of approved petitions for initial employment from three years prior. If it is *greater*, this implies that some of the approved petitions for continuing employment are for workers extending beyond six years. We take the ratio of approved continuing employment petitions to three-year-lagged approved petitions for initial employment, minus one, and averaged over the last 10 years, to provide an estimate of the fraction of workers receiving H-1B visas for initial employment who extend their stay past six years.

become available This number is, on average,1.513 times the number of petitions for initial employment three years earlier. However, it would overestimate the transition rate into 'long-term' (>6 years) H-1B status as 51.3 percent, because the ratio of petitions for continuing employment to petitions for initial employment three years earlier includes both the first H-1B extension past 6 years and additional H-1B extensions (which can be required every 3 years, or shorter intervals, for long-term H-1B holders). We estimate the transition rate *for a given cohort* by assuming a constant survival rate in H-1B status at each of the first three H-1B renewals in long-term H-1B status as $\theta = 0.35$, the solution to $1.513 = 1 + \theta + \theta^2 + \theta^3$. That is, we estimate that 35 percent of H-1B holders reaching the end of the standard six-year period of single-renewal H-1B validity will renew again after that period with an approved EB petition. This transition rate approximation is consistent with the observation that the number of continuing-employment H-1B petition approvals each year is 51.3 percent larger than the number of initial-employment H-1B approvals three years beforehand.

We call this pathway the 'front door,' because it is not the only path to long-term retention of a foreign graduate. Other pathways include shifting to an immigrant visa via marriage, other family sponsorship, or the Diversity Visa lottery; asylum; departure from the United States followed by return on a 'new' visa (such as an L-1 intracompany transfer visa; an H-1B visa via consular processing overseas, rather than change-of-status within the United States; or an EB green card visa as a new arrival, rather than change-of-status). The 'front door' includes only students who change their non-immigrant visa status to permanent resident directly, without an extended absence from the United States.

A small number of J-1 exchange visitors, in addition to the F-1 students shown in **Table 2**, manage to transition to long-term permanence. Historically, these have been small because most high-skilled J-1s were subject to the two-year home residency requirement.[37] USCIS directly reports that from 2019-2023, the average J-1 to H-1B transition rate was 6 percent. The J-1 to EB-2 (non-National Interest Waiver) and EB-3 transition rate in DOL PERM data is only 0.5 percent. We estimate the J-1 to EB transition rate to be 1 percent.

Pathways to retention

An example of the flow from the 'front door' pipeline to long-term international talent retention as illustrated in **Table 2** is shown graphically in **Figure 3**. It contains four rows or levels, proceeding forward in time from top to bottom. In the topmost (blue) level, 100 international students on F-1 visas complete a STEM degree at a U.S. U.S. university.

The second (orange) level shows how many students transition to employment under Optional Practical Training in their first 1–3 years after graduation. The third (red) level shows changes-of-status for those F-1 graduates who are able to transition directly to a non-immigrant work visa. The most important of these is the H-1B visa. "Other" (in purple) includes all other meaningful non-immigrant work visas.[38]

Finally, the lowest (green and red) level represents long-term (≥8 years) retention in the United States.
U.S. workforce. This can occur primarily through adjustment of status from a non-immigrant visa to an employment-based immigrant visa, or by long-term continuing employment on an H-1B visa for nationals

[37] More information available at https://travel.state.gov/content/travel/en/us-visas/study/exchange/waiver-of-the-exchange-visitor.html.
[38] E-3, H-1B1, O-1, TN, and a tiny fraction that pass directly from F-1 to EB-1,2,3.

Table 2: The 'Front Door' pipeline: Principal channels for transition from F-1 student visas to long-term (>6 years) work in the United States

	All		STEM		Ph.D.	
	Num.	%	Num.	%	Num.	%
Graduates (F-1), average per year 2018–2022	225,752		103,836		22,687	
Short-term (OPT)						
F-1 to OPT	121,962	54.0	66,097	63.7	15,255	67.2
F-1 but no OPT	103,790	46.0	37,739	36.3	7,432	32.8
Medium-term (non-immigrant work visas)						
OPT to H-1B	35,479	15.4	23,919	33.4	5,987	27.8
OPT to 'other' (O-1, E-3, H-1B1, TN)	2,523	1.1	864	0.8	679	3
F-1 to H-1B without OPT	19,866	8.8	14,127	13.6	2,461	10.8
F-1 to 'other' without OPT	1,204	0.5	488	0.5	327	1.4
Long-term (permanent residency, extended) H-1B)						
H-1B to EB-1, EB-2, EB-3	22,709	10.1	15,611	15.0	3,466	15.3
'Other' visa to EB-1, EB-2, EB-3	181	0.1	66	0.1	49	0.2
Extended H-1B (>6 years)	19,372	8.6	13,316	12.8	2,957	13

'All' graduates in the first column describes all completions of bachelor's, master's, or doctoral degrees in all fields of study by F-1 visa holders in a given year. 'STEM' graduates are all completions at all degree levels by F-1 visa holders in DHS-designated STEM fields only. 'Ph.D.' means all completions of doctoral degrees by F-1 visa holders in all fields, not just STEM. "%" describes the percentage of the original F-1 graduation cohort in the first row that eventually makes each transition. "Num." describes averages over the years 2018–2022. "Other" in the second to last row describes non-immigrant work visas O-1, E-3, H-1B1, and TN. The source is full-universe administrative data from SEVIS 2004–2023, obtained by request from DHS under the Freedom of Information Act.

of countries with an immigrant visa backlog.[39] At the time of writing, Indian and Chinese nationals—who make up the large majority of H-1B workers—face backlogs of 12 years for India, 5 years for China.

Figure 3 implies that 77.8 percent of foreign STEM graduates of U.S. universities enter the U.S. workforce immediately after graduation via this 'front door' pathway. This includes 63.7 percent on OPT, 13.6 percent who change status directly from F-1 to H-1B without OPT, and 0.5 percent who change status to another non-immigrant work visa category without OPT.

The transition to long-term retention via this 'front door' is much smaller. A major bottleneck is the availability of employment-based immigrant visas after the six-year maximum stay on a standard H-1B visa runs out (Jacobs 2025). About 28 percent of graduates remain in the U.S. high-skill STEM workforce 8 years later via the 'front door' pathway (**Table 2** and **Figure 3**).

[39] Under the American Competitiveness in the 21st Century Act (known as "AC21"), most nationals of countries with an approved immigrant visa petition, but for whom immigrant visas are not available due to a backlog, are exempt from the standard limit of a single, three-year extension of stay on the H-1B visa. In practice, this means that most nationals of India and China—the large majority of H-1B visa holders—can lawfully work in the United States indefinitely, as long as they have an approved immigrant visa petition.

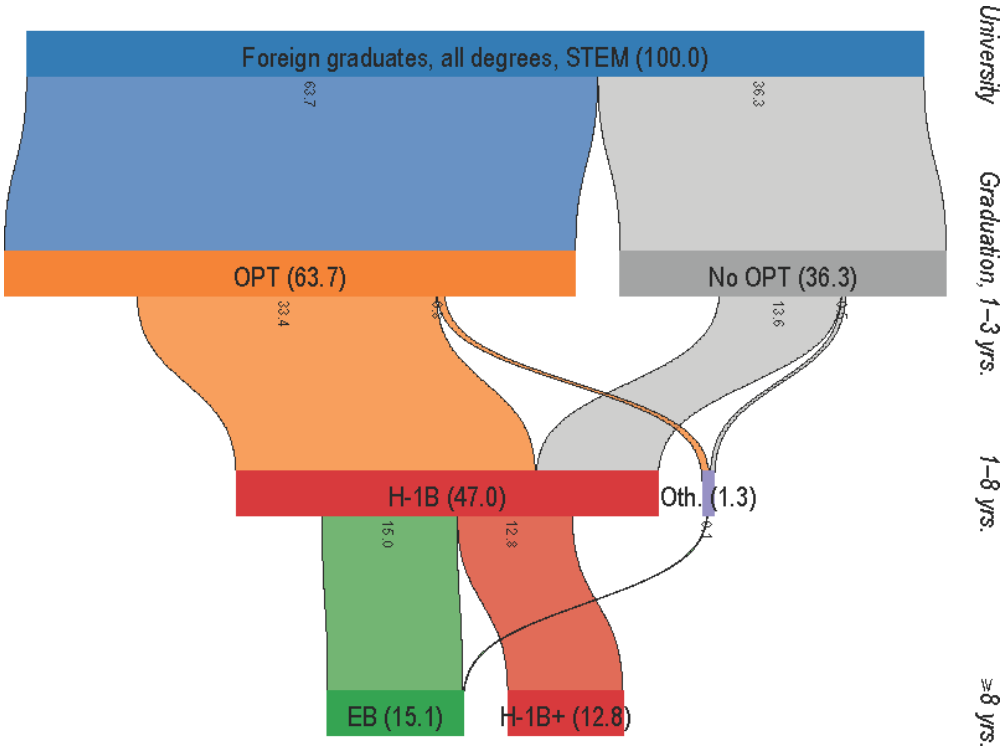


Figure 3: 'Front door' pipeline, foreign STEM graduates, all degrees. Data from Table 2. The numbers at each level describe percentages of the original cohort of 100 F-1 graduates, *not* the percentage of people in each box down the chain, as in Table 2. The transitions from the top level (students) to the second level (OPT) and third level (non-immigrant work visa) are estimated from the average rate of changes of status recorded in SEVIS between 2018 and 2022.

In **Figure 4**, we show data that describe the number of domestically-educated, foreign-born persons remaining in the United States against the number of years they have been in the United States since graduation. Any difference between those numbers describes attrition in the form of departure from the country is the most important. To control for other forms of attrition (e.g., mortality), we estimate foreign-graduate attrition relative to attrition for U.S. students (citizens and residents).[40]

This method, which should capture retention via the 'front door' and all other 'doors,' implies that 8 years after graduation, about 38 percent of nonresident alien STEM graduates at all degree levels remain in the United States. In concert with the analysis above, this implies that 74 percent of foreign STEM graduates in the United States who remain in the country long term utilize the 'front door' pathway of OPT/H-1B/EB-1,2,3 plus a small number of other work visas.

[40] Data from the National Survey of College Graduates (NSCG) and NCES IPEDS. The NSCG survey in 2023 includes the year of graduation for each person who graduated from a US university but arrived as a foreign student, by degree and field. This allows estimation of the number of people who (for example) graduated from a US university with a STEM degree in the year 2015 after arriving as a foreign student and were still present in the US in 2023 to answer the survey. Comparing this to the number of nonresident aliens who graduated with STEM degrees from US universities in the year 2015, from IPEDS, allows estimation of the fraction of that graduating cohort of foreign students who remained in the US from 2015 to 2023, that is, the eight-year retention rate.

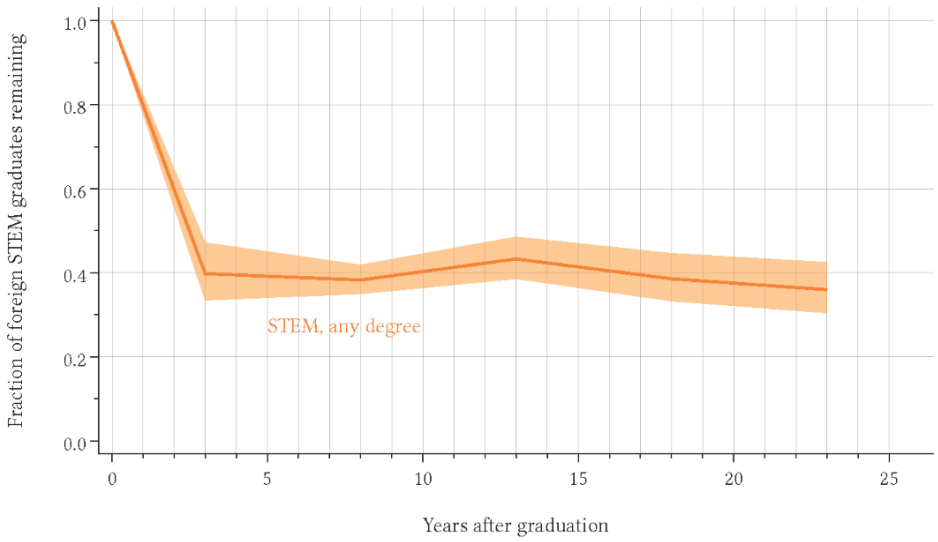


Figure 4: Rate of U.S. retention, foreign STEM graduates, all degrees. Data from the National Survey of College Graduates and IPEDS. The figure shows the estimated mean retention rate of graduation cohorts grouped into five-year intervals (the average retention rate over 1–5 years from graduation is plotted at the middle of the interval, at 3 years on the x-axis; the average retention rate over 6–10 years is plotted at the middle of the interval, at 8 years on the x-axis; and so on). The shaded area shows the interval of 95 percent statistical confidence on the estimate of the mean.

STEM Ph.D. retention

The retention pathways for foreign STEM graduates are substantially different at higher levels of education. **Figure 5** repeats the analysis of the 'front door' pathway represented by **Figure 3** specifically for graduates of Ph.D. at U.S. universities on F-1 visas. The figure includes all Ph.D. awards, both in STEM and non-STEM fields. The short-term retention rate is 79.4 percent. This includes 67.2 percent entering the U.S. workforce immediately after graduation on OPT, 10.8 percent changing status directly from F-1 to H-1B without OPT, and 1.4 percent changing to some other work visa (such as O-1) without OPT. But the long-term retention rate of Ph.D. graduates by the 'front door' path, past 8 years after graduation, is limited: just 28.5 percent.

Figure 6 repeats the overall retention analysis of **Figure 4**, for STEM Ph.D. graduates specifically (and juxtaposes it with the retention rate of all STEM degrees collectively from Figure 4, for reference). This analysis implies a retention rate, 8 years after STEM Ph.D. graduation, of 60–65 percent. This suggests that a substantial majority of STEM Ph.D. graduates who remain in the United States long term are using pathways other than the 'front door.' A common path for those working at least initially in academia appears to be a temporary departure from the U.S. after the academic year in which the doctorate was earned and return for the next academic year on another temporary visa, like H-1B, followed by adjustment later to an EB-1 immigrant visa. Another common pathway for STEM Ph.D. graduates is marriage to a U.S. citizen or permanent resident. We are not aware of available administrative data on those alternative pathways. In the analysis that follows, we rely on the rates of overall retention implied by the analysis underlying **Figures 4** and **6**.

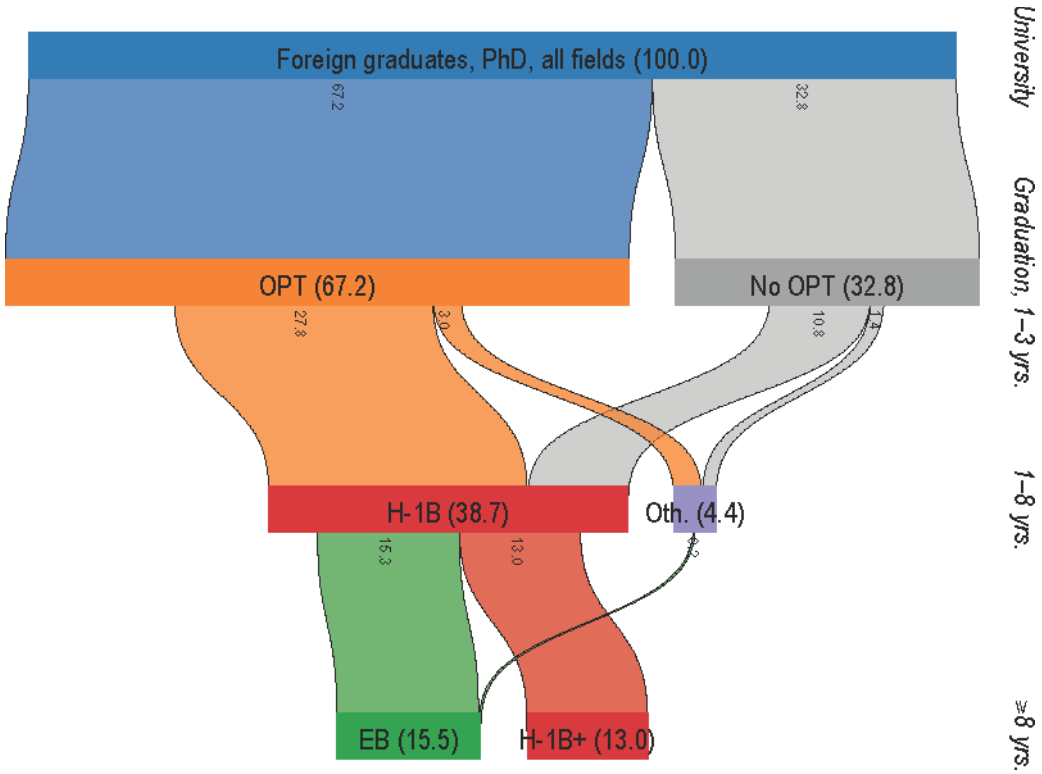


Figure 5: 'Front door' pipeline, foreign Ph.D. graduates only, STEM and non-STEM.

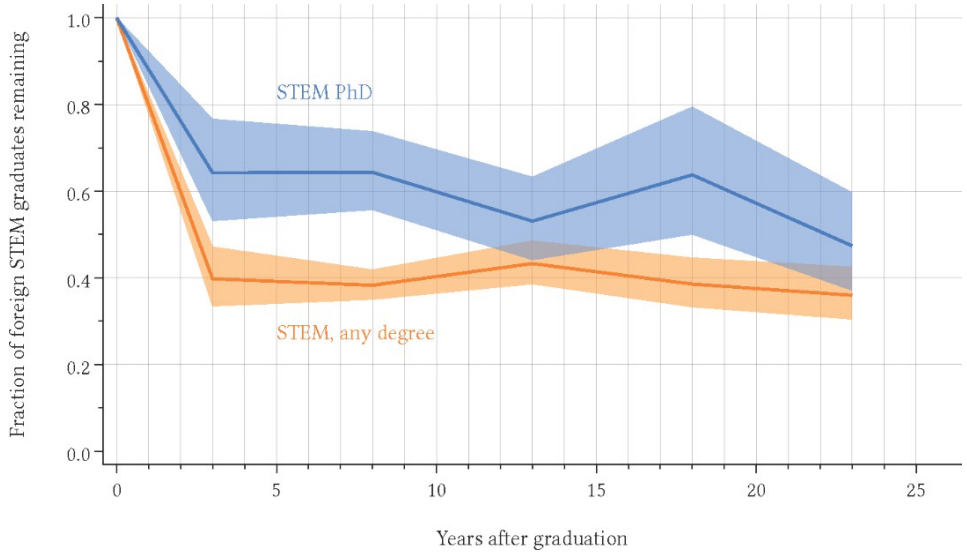


Figure 4: Rate of U.S. retention, foreign STEM graduates, Ph.D. only vs. all degrees (repeated from figure 4).

We note that the U.S. retention rate of foreign STEM Ph.D. graduates in **Figure 6** is slightly below other published estimates. We estimate a 10-year retention rate of roughly 65 percent in 2023, matching the 2021 NSB estimate (NSB 2024, 13).[41]

V. EFFECTS OF A REDUCTION IN INTERNATIONAL STUDENTS ON THE STEM WORKFORCE

The retention data described in Section IV is used here to model the short- and long-term impacts on the U.S. STEM workforce in two different scenarios: The first is a one-third reduction in the number of international STEM students entering the U.S. workforce. This scenario is intended to be indicative of the possible effects of a broad reduction in the demand for U.S. education in the face of sweeping restrictions on international students. We posit that this is a likely scenario, given the recently proposed regulations that compromise international students' ability to reliably complete their programs of study and explore options to obtain employment authorization after graduation. Alternatively, OPT rescission on its own could create this one-third decline, even under unchanged international demand for U.S. education. The second scenario is a more modest one-tenth reduction in the number of international STEM students entering the U.S. workforce. This scenario is intended to be indicative of possible effects of enacting the proposed changes to the Duration of Status rule or changes to the H-1B Seniority rule in isolation.

First scenario: One-third reduction in the number of foreign STEM graduates from U.S. universities in the U.S. labor market

The first scenario examines a one-third decline in the number of international STEM students in the U.S. labor market. As noted, this decline could arise from several potential policy changes including ending Duration of Status (D/S), rescinding all OPT, and adopting an experience-based H-1B prioritization.

International students make decisions about studying in the United States based on expected returns relative to alternative destinations. Policies changes like ending D/S increase uncertainty by raising the risk of disruption mid-degree, lowering the expected probability of program completion. Eliminating OPT removes the single largest channel for gaining career experience, recouping education costs, and developing options to transition into the U.S. workforce long-term. Without realistic access to OPT, the perceived benefit of a U.S. education is significantly reduced. Finally, prioritizing H-1Bs by seniority diminishes the probability that new graduates can transition into long-term employment in the United States.[42] Each change alters the benefit-cost calculation at the application stage, deterring enrollment. In economic terms, these policies simultaneously raise the risk of success in transitioning from enrollment to graduation (through D/S), from graduation into the short-term workforce (through OPT), and from the short-term workforce into the long-term workforce (through the H-1B), resulting in a sharp decline in the expected net present value of U.S. study. We therefore believe a one-third reduction is a conservative estimate, especially given the potential compounding effect of that suite of policies. As discussed further below, this one-third reduction could also arise simply by striking OPT, which would likely obstruct current international students from accessing the U.S. labor market after graduation.

---

[41] Others have estimated lower attrition rates for STEM Ph.D.Ph.D.s, such as five-year retention of 73 percent (NCSES 2025) and even a 10-year retention rate of 73 percent (Corrigan et al. 2022). Note that these estimates are based on the Survey of Doctorate Recipients, which relies on self-reported departures among survey respondents—a method that may underestimate departure due to higher nonresponse by those who have left the United States.

[42] Jeremy Neufeld, "The 'Wage Level' Mirage," Institute for Progress, September 24, 2025 calculates that DHS's NPRM on a weighted lottery would have reduced the number of capped H-1B slots going to F-1 graduates each year by 7 percent. A large fee would only exacerbate this effect.

Survey evidence supports this logic. In August and September 2025, two surveys asked current students and postdocs, as well as prospective students abroad, about how policy changes in the United States would change their decisions to enroll. The Current Students Survey surveyed 1,039 graduate students and postdocs on F-1 or J-1 visas and was distributed by the American Physical Society, the National Postdoctoral Association, and other professional scientific societies. While not a probability sample, it drew from a broad geographic and institutional spectrum, and the sample was heavily concentrated in STEM fields, reflecting the disciplines most tied to U.S. research and innovation. The Prospective Students Survey surveyed 611 prospective students and was distributed by three major global recruitment platforms—IDP Education, StudyPortals, and ApplyBoard. It captured applicants at different degree levels and from diverse countries of origin.

Among prospective international students, the self-reported likelihood of enrolling in U.S. programs falls by 16 percentage points with the loss of D/S (from 67 percent to 57 percent), by 29 points if OPT were rescinded (to 48 percent), and by 6 points if H-1B allocation were shifted to wage-level prioritization. For current students, retrospective counterfactuals are even starker: 49 percent said they would not have enrolled without D/S, 54 percent said they would not have enrolled without OPT, and 53 percent said they would not have enrolled if H-1Bs were seniority-based.[43] These findings indicate that the three policies each exert independent deterrent effects and support our assertion that a combined decline of roughly one-third in enrollment (without a decline in the remaining graduates' ability to transition into the labor market) represents a conservatively low estimate.

To estimate the long-term impact of a reduction in international student enrollment, we must assume that retention follows historical patterns. For example, in 2023, 34.6 percent of the high-skill STEM workforce with a Ph.D. degree was made up of workers who are foreign-born *and* received their STEM Ph.D. degree in the United States (**Figure 7**).[44] If the number of foreign STEM Ph.D. graduates from 2003-2023

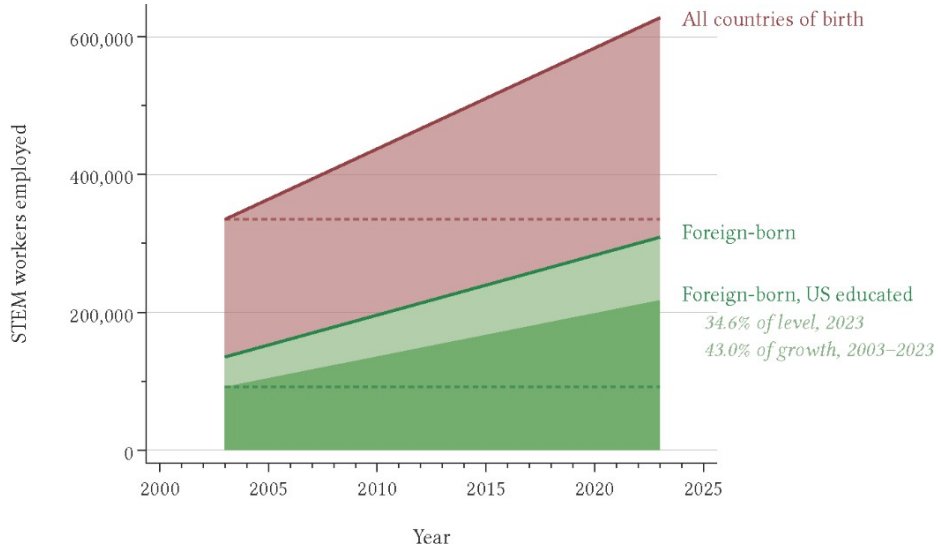


Figure 5: Immigrant prevalence of U.S. Ph.D. STEM workers (stock), 2000 versus 2023.

[43] Institute for Progress and NAFSA: Association of International Educators, "Surveys on International Talent Pipelines," September 15, 2025.
[44] Here we use data from the National Survey of College Graduates, whose sampling frame is respondent to the American Community Survey (ACS), to adjust the above ACS data on foreign-born STEM workers for country of degree. Figure 7 starts in the year 2003 because it is the year in which the National Survey of College Graduates was conducted that is closest to 2000.

had decreased by one third annually, holding retention rates constant, the number of foreign-born, U.S-educated Ph.D.-holding STEM workers in the United States would drop by 11.5 percent (i.e. one-third of 34.6 percent).

Table 3 displays the results of applying the same logic to various degree categories originally described in **Table 1**. The theoretical 11.5 percent reduction in number or *level* of STEM Ph.D.s would have resulted in a 14.3 percent reduction in the *growth* of Ph.D. STEM workers over the past two decades. Across all degrees collectively (bachelor's or higher), this could be extrapolated to a 6.2 percent reduction in the number of employed STEM graduate workers today, and a 7.6 percent reduction in the growth of foreign-born workers employed in STEM over the past two decades. For workers with a master's as their highest degree, these rates imply a long-term reduction of 9.4 percent of employed STEM workers.

An alternative way to understand the impact of a one-third reduction in international student graduates is to assess the possible immediate impacts on the U.S. workforce by a single cohort of newly graduated workers. The first stage of the graduation-to-workforce pathway in **Figure 3** implies that 77.8 percent of new foreign STEM graduates from U.S. universities, across all degree levels, directly enter the U.S. workforce the year after graduation via OPT, H-1B, or a handful of minor non-immigrant visa categories.

Table 3: Long-term impact scenario, 1/3 reduction in foreign STEM graduates

	Total employed		Foreign-born, U.S. deg.		Impact: 1/3 reduction in foreign graduates	
	2003	2023	2003	2023	Level	Growth
STEM, all degrees	3,730,767	7,837,989	532,311	1,464,701	–6.2%	–7.6%
STEM master's	1,049,766	2,339,946	225,688	659,446	–9.4%	–11.2%
STEM Ph.D.	334,926	627,638	91,477	217,226	–11.5%	–14.3%

Because foreign graduates are 20.9 percent of new graduates in STEM (**Figure 2**), this implies that a one-third reduction in foreign STEM graduates would reduce the size of the next year's cohort of new STEM workforce entrants by (–1/3 × 20.9%) × 77.8% = –5.4%. **Table 4** displays the results of applying the same logic to various degree categories. The same logic applied to newly graduated STEM master's degree recipients implies a short-term reduction of 11.0 percent. For STEM Ph.D. graduates, this short-term reduction is 11.5 percent.

We now consider a separate mechanism by which this scenario of a one-third decline could arise: OPT rescission, even while holding international demand for U.S. education constant. OPT is the critical bridge between student status and the first rung of the 'front door' talent pipeline. It buys employers up to three years (for STEM graduates) to test and mentor promising international graduates, and petition for H-1Bs

Table 4: Short-term impact scenario, 1/3 reduction in foreign STEM graduates

	Foreign graduates, 2023	Total U.S. & for. graduates, 2023	US retention of foreign grads, year 1	Short-term impact of 1/3 reduction
STEM, all degrees	187,416	897,938	77.8%	–5.4%
STEM master's	123,651	282,436	75.6%	–11.0%
STEM Ph.D.	16,905	38,794	79.4%	–11.5%

or other statuses if there is a good match. Terminating OPT would remove the only legal work authorization available to most F-1 graduates immediately after finishing their program. In the pipeline diagram, the elimination effectively seals off the direct F-1 → OPT → H-1B branch, forcing all graduates to jump straight from F-1 to another status or, far more likely, to depart. Because the H-1B cap is strict and adjudications occur months after graduation, most students who would have used OPT as a holding pattern while waiting on the lottery would face a forced exit point instead of a gateway.

Figure 3 shows that 63.7 percent of new foreign STEM graduates on F-1 visas over the last five years passed through OPT. Most of these graduates (53.7 percent or 34.2 percent of the original graduates) transitioned to another non-immigrant employment visa to stay long-term. In other words, ***OPT is by far the largest part of the 'front door' pipeline that connects foreign STEM graduates to the U.S. workforce***. Three out of four STEM graduates rely on this pipeline to remain in the country. Terminating OPT would cut off this conduit.

We can estimate the long-term impacts quantitatively by the following logic: **Figure 3** shows that 14.1 percent of new foreign STEM graduates *without* OPT can continue down the 'front door' pipeline. If terminating OPT cuts the number of students continuing down the 'front door' pipeline in half, the number of new STEM graduates entering the workforce would be 31.2 percent.[45] As described in the third level of **Figure 3**, we originally estimated this number as 48.3 percent, implying this scenario gives a reduction of 35 percent of foreign STEM graduates retained in the U.S. workforce in the long term. Revisiting the method used in **Table 3**, this implies a long-term reduction of 6–7 percent of high-skill STEM workers in the U.S. economy.

The short-term impact of OPT termination in this scenario would be larger. When OPT is an option, 77.8 percent of international STEM graduates at all degree levels enter the U.S. workforce immediately after acquiring their degree. In the absence of OPT (again, assuming that half of those who currently find visa sponsorship on OPT could do so without OPT), the immediate post-graduation workforce entry of the average STEM graduate would be, again, 31.2 percent.[46] That is, the number of new foreign STEM graduates entering the workforce immediately after graduation would fall by 59.9 percent, and the share of new graduates retained would fall by 46.6 percent. Because foreign graduates are 20.9 percent of all new STEM graduates (**Figure 2**), this would imply a reduction of 12.5 percent of the *total* number of new STEM graduates—regardless of nationality—entering the U.S. workforce directly after graduation. Both the long- and short-term shocks would be larger if fewer than half of the new graduates who find visa sponsorship on OPT could do so without OPT.

In other words, OPT rescission by itself would cause a sustained reduction in the inflow of U.S-trained foreign STEM workers into the U.S. labor force, even if demand for U.S. training remained constant. The long-term effect of that sustained reduction in inflow would be a reduction of one-third of high-skill foreign STEM graduates from U.S. universities in the U.S. economy. The effect on the U.S. labor force would thus be similar to the effect that would be expected from a one-third decline in international student inflow.

There are at least two other important mechanisms by which eliminating OPT is expected to affect the high-skilled workforce, which should be explored by future research. First, there is likely to be substitution within capped immigration categories. H-1B slots currently expected to be filled by F-1s may be filled with

---

[45] Because 14.1 percent enter the pipeline without OPT currently, and the 63.7 percent who get OPT are assumed to proceed in the pipeline at half the current rate, thus $14.1 + (63.7 \times (0.5 \times (34.2/63.7))) = 31.2$.

[46] This number comes from: $(34.2 \times 0.5) + 14.1$.

new immigrants, mitigating the aggregate long-term effect on the workforce (though still contributing a short-term shock). That substitution is likely to reduce the average productivity of H-1Bs if not their number. Second, because OPT and U.S. work authorization are part of the value proposition for students, a fuller model would incorporate enrollment feedback whereby fewer prospective students decide to come to the United States. This enrollment feedback would likely be significant, and we consider the one-third reduction described in the first scenario a conservative estimate of that effect.

Second scenario: One-tenth reduction in the number of foreign STEM graduates from U.S. universities entering the U.S. labor market

If some of the new suite of restrictive policies were to be enacted but not others, we presume a smaller effect on the number of high-skill foreign STEM workers in the U.S. workforce. We adapt the above estimation method to this scenario of more limited impact and discuss its relation to two specific restrictions: the Duration of Status rule and the H-1B seniority prioritization rule.

Eliminating D/S and replacing it with a fixed period of stay would fundamentally alter the incentives and conditions at the entry point of the 'front door' of the talent pipeline. D/S impacts the decision to enroll in a U.S. degree program in the first place, the ability to complete the program, and the incentive to extend status for OPT.

We conservatively estimate that the D/S rule by itself would cause a 10 percent reduction in new enrollments of F-1 students in degree-granting programs, and thus the number of STEM graduates eventually entering the U.S. labor force. Recent survey evidence suggests a substantially larger deterrence effect. In the surveys discussed above, 49 percent of current students reported they would not have enrolled in the United States without D/S, and 29 percent of prospective students abroad said the loss of D/S alone would deter them from coming. DHS's proposal replaces automatic D/S coverage with a new system of required Extensions of Stay (EOS) for all F-1 and J-1 students seeking to participate in Optional Practical Training (OPT) or STEM OPT. DHS projects that this would generate 220,122 new EOS filings annually for F-1s and 240,583 for J-1s, and seemingly anticipates adjudication delays of 240 days or longer.[47] These administrative changes compound the deterrent effect of the rulemaking.

These changes would introduce substantial uncertainty about whether students could maintain status long enough to begin OPT or STEM OPT. Because timely work authorization is essential for recouping education costs and gaining experience in a student's field of study, such uncertainty is likely to deter both enrollment and retention. In practice, the proposed rule would transform a predictable progression from study to employment into a sequence of precarious renewal points, magnifying perceived risk and lowering the expected return to study in the United States.

Separately, reordering H1-B selection by seniority would also fundamentally alter the 'front door' pipeline. The H-1B visa is the primary bridge between short-term post-graduation employment authorization and longer-term work in the United States. The overwhelming majority of F-1 STEM scholars who stay in the United States utilize the H-1B to secure long-term status. Only 0.1 percent of graduates who use the 'front door' pipeline manage to bypass the H-1B and stay for over 8 years via alternative visas (see Figure 3).

---

[47] 90 Fed. Reg. 42070 (Aug. 28, 2025).

The proposal to reorder H-1B selection by seniority would substantially narrow this bridge by favoring older, later-career workers over early-career recent graduates. New graduates are disproportionately concentrated at early-career prevailing wage levels even in high-paying occupations. In fact, even though F-1 students get H-1Bs petitions filed on their behalf with higher compensation on average than other H-1B beneficiaries, they are classified at lower Department of Labor prevailing wage levels because they are early career in higher-paying occupations (Neufeld 2025). The result of a reviewed H-1B selection by seniority is estimated to reduce the share of H-1B visas going to F-1 students by 7 percent.

As previously established, among recent graduating cohorts, an average of 35,479 students transitioned from F-1 visas to H-1Bs while on OPT, and another 19,866 who did so without using OPT, for a total of 55,345 students (see **Table 2**). Given variation in the time between graduation and securing an H-1B, the entire cohort will not make that transition simultaneously. However, because there is a cohort each year, we can assume a long-run flow of 55,345 H-1Bs to F-1s per year under the status quo.

First, we must determine the pool of affected H-1Bs.[48] Recent data obtained through the Freedom of Information Act[49] indicate that an average of 47,189 cap-subject H-1Bs were filed and approved on behalf of F-1 students between FY2021 and FY2024. Using this data to simulate the effects of the lottery while applying the proposed H-1B rule suggest 6.91 percent fewer cap-subject H-1Bs would have been given to F-1 students each year (Neufeld 2025).[50] Looking at both cap-subject and cap-exempt employers, that would translate into 5.9 percent fewer transitions from F-1 → H-1B and OPT → H-1B each year.

How would a 5.9 percent decline in the transition rate affect the economy? Three key effects must be considered. First, the lower transition rate will directly reduce the retention of foreign graduates. Second, the reduced likelihood of securing a visa will generate enrollment feedback whereby the reduced likelihood of getting an H-1B slot deters students from enrolling in the first place. The survey results described above indicate this may result in a one-tenth reduction in the number of foreign STEM graduates from U.S. universities in the U.S. labor market. Third, the proposed counterfactual would not eliminate those slots that students will lose, but redistribute them to other workers, causing changes in the composition of H-1B recipients. Cap-subject H-1Bs are zero-sum, so—all else equal—H-1Bs will be awarded to others instead. For example, the recent I-129 H-1B filing data show that large American multinational firms file a large percentage of their initial cap-subject H-1Bs for other, non-student visa holders who need H-1Bs to continue working in the United States while awaiting green card status.[51] This cohort and other H-1B beneficiaries will mitigate the effects on the workforce, but perhaps not as much as might be assumed. Initial cap-subject H-1Bs filed on behalf of F-1s are paid more on average than other workers, and F-1 beneficiaries are younger on average than other beneficiaries. Furthermore, the rule will have significant effects on the distribution of H-1Bs to those entirely outside of the 'front door' pipeline. These complicating factors lead us to conclude that we cannot judge the long-term effect on the size of the STEM workforce from only the effect on the 'front door.'

---

[48] While most employers are subject to numerical caps in the number of H-1B visas allocated, some are deemed H-1Bs cap-exempt. For example, the H-1B cap does not apply to initial employment at nonprofit organizations or universities.
[49] Obtained by Bloomberg via I-129 H-1B filing.
[50] Using the methodology of Neufeld (2025).
[51] AC21 provides that individuals approved for green card classification by employer petitions may extend their H-1B status indefinitely while awaiting immigrant visa availability. This pathway is not available for all visa holders.

VI. RESPONSES BY OTHER STEM WORKERS

The above scenarios are mechanistic impacts. To interpret these as indicative of causal impacts requires assumptions that must be examined. One of the most important involves the possible changes in immigration patterns of foreign-educated foreign workers. A second involves the possible changes in immigration patterns of domestically born U.S. students. Here we consider existing evidence on each.

Substitution by foreign-trained STEM workers

If a portion of U.S-educated foreign workers disappear from the U.S. workforce, to what degree will foreign-trained foreign workers substitute for them? In the 'front door' pipeline of Figure 3, this substitution could be substantial. The number of H-1B visas each year for initial employment in the private sector has been capped at 85,000 since 2005. The number of employment-based visas in the relevant categories has been capped at 120,120 since 1990. There is complexity to these caps: the H-1B cap does not apply to initial employment at nonprofit organizations or universities; the employment-based visa cap can vary from year to year and may include reallocations of unused family-reunification visas from prior years.
Regardless of where they are educated, there are binding constraints on the supply of H-1B non-immigrant employment visas and EB immigrant visas for permanent residency for most foreign workers. Thus, it is possible that reductions in the number of U.S-trained foreign STEM workers receiving these visas could increase the number of foreign-trained STEM workers receiving them.

However, the experience of recent years is inconsistent with substitution of this kind. In 2008, the administration of George W. Bush extended OPT for STEM graduates from 12 months to 29 months.[52] The effect of this change was to greatly expand the number of foreign STEM graduates working in the United States on OPT: the number rose by a factor of six by 2019 relative to its level in 2007, before which it had not been rising (**Figure 8**, in solid red). This caused a large increase in the number of U.S-educated foreign STEM workers studying in the United States who were seeking H-1B visas (Demirci 2019, Amuedo-Dorantes et al. 2023). The number of H-1B visas available to private sector employers was fixed at 85,000 in 2005 and did not rise thereafter. If the post-2008 rise in the number of STEM OPT workers represented (far) more workers competing for a fixed supply of visas, the probability that any given OPT worker changed status to a H-1B visa would naturally fall.

This did not, however, occur. The SEVIS data show that the rate of transition of STEM graduates from F-1 visas to H-1B visas *rose*, whether overall or conditional on OPT employment (**Figure 8**, in dashed green). The average rate of transition from F-1 to H-1B was higher in the pre-COVID years of 2010–2019 than before OPT was extended in 2008. This is consistent with large numbers of foreign graduates pursuing uncapped H-1B visas outside the private sector in response to shifts in demand (Amuedo-Dorantes and Furtado 2019). It is inconsistent with the fixed supply of H-1B visas accessible to U.S-educated foreign STEM workers.

The large increase in U.S-educated foreign STEM graduates seeking H-1B visas also did not reduce new H-1B workers arriving from abroad. **Figure 9** shows the annual cohort numbers of H-1B workers with an approved petition for initial employment in orange ("All initial"). It also shows the portion who changed

[52] 73 Fed. Reg. 18944 (April 8, 2008).

Figure 6: STEM graduates on OPT and transitions to H-1B, pre-COVID. Data from DHS SEVIS, obtained by request under the Freedom of Information Act. "Fraction changing status to H-1B" indicates the fraction that has ever changed status from F-1 to H-1B in any subsequent year, not instantaneous transition rates.

status to H-1B through consular processing overseas rather than in the United States, in purple ("From abroad"). The latter is a good indicator of the number of H-1B workers starting employment in the United States after training abroad, rather than after training in the United States. **Figure 9** reveals dips in these arrivals as the Great Recession hit in 2009, and amid tightened H-1B restrictions by the first Trump administration in 2018.

There is little sign that participation of foreign-educated foreign workers was systematically *lowered* between 2011 and 2017, when the quantity of OPT STEM workers in the United States was high (**Figure 8**), compared to the years before 2008. If the greatly expanded supply of U.S-educated OPT workers was

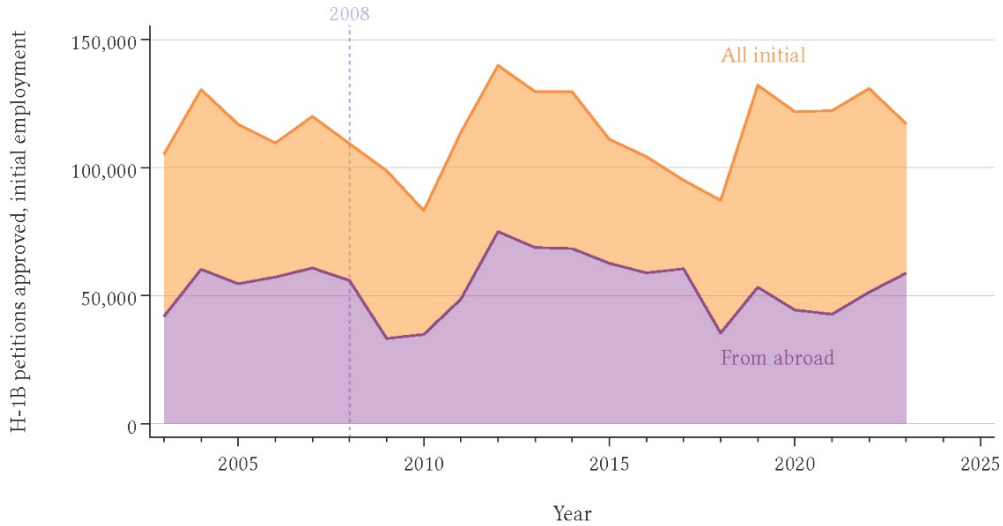


Figure 9: New-arrival H-1B workers from abroad, pre-COVID years. Data on total approved petitions for initial-employment H-1B visas, and the subset of approved petitions from abroad ('Aliens outside the US'), from U.S. Citizenship and Immigration Services, *Characteristics of H-1B Specialty Occupation Workers, Report to Congress*, U.S. Dept. of Homeland Security, various years.

competing for a fixed supply of H-1B visas, we would expect a great reduction in the availability of those visas for foreign-trained workers. The evidence in **Figure 9** is inconsistent with such competition being a major determinant of the supply of foreign-trained STEM workers competing for the same pipeline.

Together, **Figures 8** and **9** are inconsistent with the idea that the large expansion of U.S-trained foreign graduates entering the U.S. workforce after 2008 substituted for foreign-trained workers. This evidence is indirectly inconsistent with the presumption that the reverse experiment—a large reduction in the supply of foreign graduates entering the U.S. workforce—would be automatically substituted for by foreign-trained workers. This suggests that even the purely mechanical impact scenarios in the preceding section are informative. This indirect evidence is not definitive, however, and should be the subject of further inquiry.

Substitution by U.S-born and U.S-resident workers

A large reduction in the supply of U.S-educated foreign STEM workers could cause an offsetting increase in the supply of U.S-born and U.S-resident STEM graduates. This can be tested empirically: if declines in the supply of international students tend to 'crowd in' U.S. students, we should observe that rises in the supply of international students 'crowd out' U.S. students.

A large body of research has investigated this possibility and has not found evidence that international students systematically crowd out U.S. students at the national level (Borjas 2007, Jackson 2015, Shen 2016). Except for some heterogeneous effects for specific subgroups of the population,[53] no evidence has been found that international students systematically crowd out U.S. STEM students either (Ransom and Winters 2021; Orrenius and Zavodny 2015).

In fact, positive shocks to foreign student enrollment due to a *force majeure* cause general increases in native student enrollment, in part because revenue from foreign student tuition allows universities to expand programs available to all students, including U.S-born student students (Shih 2017, Bound et al. 2020). Increases in the foreign STEM workforce of U.S. cities lead U.S-born workers to specialize in socially-intensive tasks within occupations but does not reduce the supply of STEM tasks (Lin 2019). In other words, the prevalence of foreign STEM workers causes U.S. workers to adjust their personal task contents in ways that create greater complementarity with foreign workers, offsetting competition that might have dissuaded natives from studying STEM fields. This is likely why the 2008 expansion of OPT caused an overall *increase* in the wages of native STEM workers (Demirci 2020, *Appendix*), increasing the incentives for U.S. students to study STEM fields.

A limited set of studies has found crowd-out of native STEM students by immigrant STEM students, exclusively at the leading and most selective elite research universities where slots are rationed (Borjas 2007, Shen 2016, Anelli et al. 2023). Such an effect arises mechanically for any resource whose supply is fixed in the short term, such as the number of seats available for a freshman mathematics course at Yale University: a rise in the prevalence of students in any group tautologically requires a decline in the number of students in any other group. However, the number of slots in university courses in general, or STEM courses in particular, is not fixed at the national level (Jackson 2015). **Figure 2** vividly illustrates this: the supply of U.S. higher education in STEM has skyrocketed along with demand in recent decades. Findings that admission slots at elite colleges are fixed in the short run do not inform whether slots in

[53] These effects are beyond the scope of this paper. See, for example, https://edworkingpapers.com/sites/default/files/ai25-1207.pdf

STEM training are fixed at the national level, even in the short run. Thus, these studies are not informative about generalized crowding out or crowding in of native STEM students by foreign STEM students.

In short, the evidence we have does not suggest that foreign STEM students at U.S. universities are competing with U.S-born students for a fixed number of classroom slots before they graduate, nor are they competing with foreign-educated foreign workers for a fixed number of work permits after graduation.

VII. EFFECTS ON U.S. GROWTH AND PRODUCTIVITY

The research literature provides strong and consistent evidence that high-skill immigration drives U.S. productivity and economic growth, with the largest effects from STEM-trained immigrants. The increase in U.S. city-level productivity caused by inflows of foreign STEM workers from 1990 to 2010 is sufficient in magnitude to explain between 30 and 50 percent of *all* aggregate productivity growth in the United States during that period (Peri et al. 2015). The leading economists who consider all available policy levers to raise productivity in the United States conclude that the single lever with the greatest impact on productivity—demonstrated by the most conclusive evidence—is policy to encourage high-skill immigration (Bloom et al. 2019).

Moreover, high-skill immigrants enable innovation *by U.S-born* workers. Beine et al. (2024) find that roughly one-third of the positive effect of foreign master's graduates on U.S. entrepreneurship arises from businesses started by U.S-born business owners. Thus, a very large and essentially uncontested body of research finds that these positive effects on productivity and growth arise from high-skill STEM immigrants' effects on new business formation, scientific discovery, and the patenting of new economic ideas.

Increases in foreign-born master's graduates driven by an unrelated *force majeure* cause more entrepreneurship in exposed regions, including by U.S-born entrepreneurs (Beine et al. 2024). High-skill workers who entered the United States on student visas have much larger rates of patenting, publishing, earning, and entrepreneurship than otherwise comparable U.S-born high skilled workers (Hunt 2011). Foreign STEM Ph.D. students report a greater preference for entrepreneurship than their U.S-born colleagues (Roach et al. 2019). Historical increases in barriers against skilled immigration caused reduced scientific productivity in the United States as a whole (Moser et al. 2014, 2025). Increases in foreign STEM Ph.D. student inflows to the United States, driven by unrelated shocks overseas, cause increased innovation and discovery in U.S. academic departments (Stuen et al. 2012, Gaulé and Piacentini 2013).

Beyond the general recognition that many highly educated immigrants increase innovation with their own new ideas, immigrant inventors cause their U.S-born colleagues to patent more new ideas (Bernstein et al. 2022). In other words, high-skill immigrants not only bring their own innovative talents but also make entire firms and even regions more innovative. Increases in foreign STEM worker prevalence cause increased patenting in U.S. cities (Kerr and Lincoln 2010, Winters 2014) and increased entrepreneurship in U.S. regions (Tareque et al. 2024). At U.S. firms, increased employment of high-skill U.S. workers (Kerr et al. 2015) increases product innovation (Khanna and Lee 2019) and entrepreneurial success (Dimmock et al. 2022). The effect of university-educated immigrant inflows on innovation is large enough to raise United States GDP by 1.4 to 2.4 percentage points over a decade (Hunt and Gauthier-Loiselle 2010). Together with language ability and the tacit knowledge of U.S. workers for socially-intensive tasks at work, this evidence points to a comparative advantage for STEM occupations to include highly educated

foreign workers (Hanson and Slaughter 2017). This specialization is an emergent feature of groups that include both immigrant and U.S. workers.

Because high-skill immigrants spark new activity and productivity for entire firms, cities, and regions, it may not be surprising that their arrival causes increases in the demand for low-skill workers as well. High-skill STEM immigrant inflows cause increases in the employment (Kemeny and Osman 2018) and wages (Peri et al. 2015) of U.S. workers without a high school degree. This positive effect is generally applicable to the effects that concentrated populations of high-skilled workers have on less-skilled workers (Winters 2013).

This literature collectively suggests that a substantial reduction in the supply of foreign talent to the U.S. workforce will have large, adverse, and lasting effects on productivity and economic growth in the United States. We can approximate the magnitude of those effects using the productivity effects estimated by Peri et al. (2015), who compare the elasticity of annual growth (Total Factor Productivity [TFP]) to the share of the workforce comprising high-skill foreign STEM workers. They estimate that an increase of 0.27 to 0.54 percent in annual TFP growth is caused by each percentage point increase in high-skill immigrant STEM workers as a fraction of the overall labor force.

Effects of a one-third decline in the number of U.S-trained high-skill foreign STEM workers in the U.S. economy

We can use the above TFP estimate to consider the overall economic growth impact implied by the impact scenarios from **Table 3**. There, an ongoing reduction of one-third in the number of foreign STEM graduates from U.S. universities reduces the supply of high-skill STEM workers in the United States by 6.2 percent. Because the 8 million high-skill STEM workers overall represent 4.7 percent of the U.S. labor force, a 6.2 percent reduction in high-skill foreign STEM workers equates to a 0.29 percent change in high-skill STEM workers as a fraction of the labor force.

The Peri et al. elasticity thus implies a reduction of 0.079 to 0.158 percent in annual TFP growth, in this scenario. This is comparable in magnitude to the independent estimates of Hunt and Gauthier-Loiselle (2010). Together, with the effects jointly implied by Kerr and Lincoln (2010) and Peri et al. (2015), these represent the best available evidence on the macroeconomic effects of high-skill foreign STEM workers' presence in the United States economy.

This is a very large impact, which accumulates overtime. Over a ten-year period, lost annual productivity growth of 0.079 to 0.158 percent causes GDP at the end of that decade to be 0.79 to 1.57 percent smaller. This is a percent decline in annual GDP, not a percentage-point decline in annual growth of GDP. That reduction in GDP equates in size to the loss the U.S. economy would suffer from the disappearance of the entire economy of South Carolina (about 1.2 percent of national GDP), Utah (1.0 percent of national GDP), or Wisconsin (1.5 percent of national GDP).

If such a loss occurred today, amid the United States's $30.4 trillion economy, it would be valued at $240 to 481 billion.[54] As discussed in the first scenario of Section V above, this estimate is informative about the effect of a sustained decline of one-third due to two impacts that are conceptually distinct: 1) reduction

[54] In the most recent data available at the time of writing, the GDP of the United States in fiscal 2025Q2 was $30.35 trillion: US Bureau of Economic Analysis, Gross Domestic Product[GDP], retrieved from FRED, Federal Reserve Bank of St. Louis, September 18, 2025, available at https://fred.stlouisfed.org/series/GDP.

in international demand for U.S. higher education due to the full suite of new restrictions on international students or 2) the mechanical effect of OPT rescission on international students' transitions into the U.S. labor force, holding demand for U.S. higher education constant.

Effects of a one-tenth decline in the number of U.S-trained high-skill foreign STEM workers in the U.S. economy

We now consider the more modest impact of a one-tenth decline in the number of U.S-trained high-skill foreign STEM workers in the U.S. labor force. As discussed in the second scenario above, this provides insight into the effect of enacting D/S in isolation or enacting seniority-based H-1B prioritization.

Following the same methodology for larger impacts above, this would reduce the total supply of high-skill STEM workers in the United States by 1.9 percent, or a 0.09 percent change in high-skill STEM workers as a fraction of the labor force. The Peri et al. (2015) elasticity thus implies a reduction of 0.024 to 0.048 percent annual TFP growth in this scenario. This impact, too, is very large and cumulates over time. Over a ten-year period, lost annual productivity growth of 0.024 to 0.048 percent causes GDP at the end of that decade to be 0.239 to 0.478 percent smaller. Again, this is a percent decline in annual GDP, not a percentage-point decline in the annual growth of GDP.

If such a loss occurred today, amid the United States's $30.4 trillion economy, it would be valued at $72 to 145 billion. That reduction in GDP equates in size to the loss the U.S. economy would suffer from the disappearance of the entire economy of the state of Delaware, New Hampshire, or the entire Research Triangle metropolitan area.

VIII. CONCLUSION

The challenges facing America's high-skill immigration system have implications far beyond elite universities or coastal hubs. The impacts ripple through innovation clusters nationwide, threatening not just individual institutions but entire regional economies built around science, technology, and higher education. While Silicon Valley in California and Kendall Square in Massachusetts capture imaginations, the dependence on international talent spans the American map. The South's growing technology corridors—from North Carolina's Research Triangle to Texas's emerging tech centers—depend on international talent pipelines to compete globally. Even smaller metropolitan areas like Rochester, New York, and Madison, Wisconsin, have built innovation economies around universities that attract significant international student populations.

The 2025 Global Innovation Index identifies 22 U.S. clusters among the world's top 100 science and technology clusters, demonstrating the geographic diversity of American innovation (WIPO, 2025). These clusters include Austin, Cincinnati, Denver-Boulder, Pittsburgh, and Raleigh-Durham, as well as San Jose-San Francisco and Boston-Cambridge. Each relies heavily on the international student pipeline to maintain their competitive edge. About 23 percent of international students who earn a master's degree remain in the United States after graduation to work in the same state as the university they attended (Beine et al. 2024). This retention creates regional clusters of expertise that support both established companies and startup formation. But retention varies widely by geography. Between 2012 and 2020, the Mid-Atlantic lost more than 100,000 foreign-born bachelor's graduates, 180,000 foreign-born master's graduates, and 10,000 foreign-born Ph.D.s, including migration to other regions (O'Brien 2024). The Northeast does even worse with retention. Meanwhile, the West Coast performs the best, but the Midwest and South significantly outperform the Northeast and Mid-Atlantic.

Informed policy-making also requires better information. The U.S. lacks comprehensive data on immigration flows, transitions, retention rates, and economic impacts at the regional level. Improved tracking and renewing efforts like the New Immigrant Survey, which briefly collected longitudinal data, would enable evidence-based policymaking. Existing surveys like the National Science Foundation's National Center for Science and Engineering Statistics surveys, which provide rich information on STEM graduates and the workforce, need to be strengthened to help researchers, policy makers, and social scientists better understand stay rates. This can be accomplished by providing data on nonresponse rates, adding questions related to emigration, and resolving ambiguities in existing immigration-related questions. Our estimates are a start based on existing information, but better data would allow more accurate and granular estimates of flows (and their characteristics) throughout the entire immigration system.

Current system dysfunction creates a dangerous feedback loop. As wait times grow and uncertainty increases, fewer top candidates choose the United States as their preferred destination. Meanwhile, as other countries modernize their immigration systems, they will actively recruit the talent that America is losing. If current policy measures to deter foreign students from coming to the United States succeed, they will leave a large and lasting hole in the high-skill STEM workforce, in the national capacity to innovate, and in the prosperity of future generations.

REFERENCES

Amornsiripanitch, Natee, Paul A. Gompers, George Hu, and Kaushik Vasudevan. "Getting schooled: Universities and VC-backed immigrant entrepreneurs." *Research Policy* 52, no. 7 (2023): 104782.

Amuedo-Dorantes, Catalina, Kevin Shih, and Huanan Xu. "The implications of optional practical training reforms on international student enrollments and quality." *Economic Inquiry* 61, no. 2 (2023): 253-281.

Amuedo-Dorantes, Catalina, and Delia Furtado. "Settling for Academia?: H-1B visas and the career choices of international students in the United States." *Journal of Human Resources* 54, no. 2 (2019): 401-429.

Anelli, Massimo, Kevin Shih, and Kevin Williams. "Foreign students in college and the supply of STEM graduates." *Journal of Labor Economics* 41, no. 2 (2023): 511-563.

Beine, Michel, Giovanni Peri, and Morgan Raux. "The Contribution of Foreign Master's Students to U.S. Start-Ups." No. w33314. National Bureau of Economic Research, 2024.

Bernstein, Shai, Rebecca Diamond, Abhisit Jiranaphawiboon, Timothy McQuade, and Beatriz Pousada. "The contribution of high-skilled immigrants to innovation in the United States." No. w30797. National Bureau of Economic Research, 2022.

Bloom, Nicholas, John Van Reenen, and Heidi Williams. 2019. "A Toolkit of Policies to Promote Innovation." *Journal of Economic Perspectives* 33 (3): 163–84. DOI: 10.1257/jep.33.3.163

Borjas, G. (2007). "Do foreign students crowd out native students from graduate programs?", in (P. Stephan and G. Ehrenberg, eds.), *Science and the University*, pp. 134–49, Madison: University of Wisconsin Press.

Bound, John, Breno Braga, Gaurav Khanna, and Sarah Turner. "A passage to America: University funding and international students." *American Economic Journal: Economic Policy* 12, no. 1 (2020): 97-126.

Bound, John, Breno Braga, Gaurav Khanna, and Sarah Turner. "The globalization of postsecondary education: The role of international students in the U.S. higher education system." *Journal of Economic Perspectives* 35, no. 1 (2021): 163-184.

Corrigan, Jack, James Dunham, and Remco Zwetsloot. "The long-term stay rates of international STEM Ph.D. graduates." Center for Security and Emerging Technology. (2022).

Demirci, Murat. "Transition of international science, technology, engineering, and mathematics students to the U.S. labor market: The role of visa policy." *Economic Inquiry* 57, no. 3 (2019): 1367-1391.

Demirci, Murat. "International students and labour market outcomes of US-born workers." *Canadian Journal of Economics/Revue canadienne d'économique* 53, no. 4 (2020): 1495-1522.

Dimmock, Stephen G., Jiekun Huang, and Scott J. Weisbenner. "Give me your tired, your poor, your high-skilled labor: H-1B lottery outcomes and entrepreneurial success." *Management Science* 68, no. 9 (2022): 6950-6970.

Ganguli, Ina and Megan MacGarvie, "International Students, Immigration Policies and Implications for Innovation" Working Paper 34212, Cambridge, MA: National Bureau of Economic Research (2025).

Gaulé, Patrick, and Mario Piacentini. "Chinese graduate students and U.S. scientific productivity." *Review of Economics and Statistics* 95, no. 2 (2013): 698-701.

Glennon, Britta. "Skilled immigrants, firms, and the global geography of innovation." *Journal of Economic Perspectives* 38, no. 1 (2024): 3-26.

Hanson, Gordon H., and Matthew J. Slaughter. "High-skilled immigration and the rise of STEM occupations in U.S. employment." *Education, skills, and technical change: Implications for future U.S. GDP Growth*, pp. 465-494. University of Chicago Press, 2017.

Hunt, Jennifer. "Which immigrants are most innovative and entrepreneurial? Distinctions by entry visa." *Journal of Labor Economics* 29, no. 3 (2011): 417-457.

Hunt, Jennifer, and Marjolaine Gauthier-Loiselle. "How much does immigration boost innovation?" *American Economic Journal: Macroeconomics* 2, no. 2 (2010): 31-56.

Jackson, Osborne. "Does Immigration Crowd Natives into or out of Higher Education? Working Papers. No. 15-18." Federal Reserve Bank of Boston (2015).

Jacobs, Elizabeth M. "Greener pastures: why Indian international students leave the U.S. labor market." *Journal of Ethnic and Migration Studies* 51, no. 5 (2025): 1346-1370.

Jaravel, Xavier, Neviana Petkova, and Alex Bell. "Team-specific capital and innovation." *American Economic Review* 108, no. 4-5 (2018): 1034-1073.

Kemeny, Tom, and Taner Osman. "The wider impacts of high-technology employment: Evidence from U.S. cities." *Research Policy* 47, no. 9 (2018): 1729-1740.

Kerr, William R., and William F. Lincoln. "The supply side of innovation: H-1B visa reforms and U.S. ethnic invention." *Journal of Labor Economics* 28, no. 3 (2010): 473-508.

Kerr, Sari Pekkala, William R. Kerr, and William F. Lincoln. "Skilled immigration and the employment structures of U.S. firms." *Journal of Labor Economics* 33, no. S1 (2015): S147-S186.

Khanna, Gaurav, and Munseob Lee. "High-skill immigration, innovation, and creative destruction." *The roles of immigrants and foreign students in U.S. science, innovation, and entrepreneurship*, pp. 73-98. University of Chicago Press, 2019.

Lin, Gary C. "High-skilled immigration and native task specialization in U.S. cities." *Regional Science and Urban Economics* 77 (2019): 289-305.

Moser, Petra, Alessandra Voena, and Fabian Waldinger. "German Jewish émigrés and U.S. invention." *American Economic Review* 104, no. 10 (2014): 3222-3255.
Moser, Petra, Sahar Parsa, and Shmuel San. "Immigration and Innovation: Lessons from the Quota Acts." (2025). Working paper, Dept. of Economics. New York University.
Mukhopadhyay, Sankar, and David Oxborrow. "The value of an employment-based green card." *Demography* 49, no. 1 (2012): 219-237.
NCSES, National Center for Science and Engineering Statistics. 2025. "Most U.S-Trained Science and Engineering Doctorate Recipients on Temporary Visas Remain in the United States." NSF 25-325. National Science Foundation. Available at https://ncses.nsf.gov/pubs/nsf25325.
Neufeld, Jeremy. "The 'Wage Level' Mirage," Institute for Progress (2025).
NSB, National Science Board, National Science Foundation. 2024. "Science and Engineering Indicators 2024: The State of U.S. Science and Engineering." NSB-2024-3. Available at https://ncses.nsf.gov/pubs/nsb20243.
NSF, "The STEM Labor Force: Scientists, Engineers, and Skilled Technical Workers" NSB-2024-5, *Science and Engineering Indicators 2024,* Washington, DC: National Science Foundation.
O'Brien, Connor. "Most international graduates of American universities ultimately leave the U.S.," Economic Innovation Group (2024). Available at: https://eig.org/immigrant-retention-estimates/.
Orefice, Gianluca, Anna Maria Mayda, and Gianluca Santoni. "Skilled Immigration, Task Allocation and the Innovation of Firms." *CEPR Discussion Papers*, No. 17662. 2022.
Orrenius, Pia M., and Madeline Zavodny. "Does immigration affect whether U.S. natives major in science and engineering?" *Journal of Labor Economics* 33, no. S1 (2015): S79-S108.
Peri, Giovanni, Kevin Shih, and Chad Sparber. "STEM workers, H-1B visas, and productivity in U.S. cities." *Journal of Labor Economics* 33, no. S1 (2015): S225-S255.
Ransom, Tyler, and John V. Winters. "Do foreigners crowd natives out of STEM Degrees and occupations? Evidence from the U.S. Immigration Act of 1990." *ILR Review* 74, no. 2 (2021): 321-351.
Roach, Michael, Henry Sauermann, and John Skrentny. "Are foreign STEM Ph.D.s more entrepreneurial? Entrepreneurial characteristics, preferences, and employment outcomes of native and foreign science and engineering Ph.D. students." *The Roles of Immigrants and Foreign Students in U.S. Science, Innovation, and Entrepreneurship*, pp. 207-228. University of Chicago Press, 2019.
Ruggles, Steven, Sarah Flood, Matthew Sobek, Daniel Backman, Grace Cooper, Julia A. Rivera Drew, Stephanie Richards, Renae Rodgers, Jonathan Schroeder, and Kari C.W. Williams. *IPUMS USA: Version 16.0* [dataset]. Minneapolis, MN: IPUMS, 2025. Available at: https://doi.org/10.18128/D010.V16.0.
Shen, Ying (2016), "The impacts of the influx of new foreign undergraduate students on U.S. higher education" Working Paper, University of Notre Dame.
Shih, Kevin. "Do international students crowd-out or cross-subsidize Americans in higher education?" *Journal of Public Economics* 156 (2017): 170-184.
Stuen, Eric T., Ahmed Mushfiq Mobarak, and Keith E. Maskus. "Skilled immigration and innovation: evidence from enrolment fluctuations in U.S. doctoral programmes." *Economic Journal* 122, no. 565 (2012): 1143-1176.
Tareque, Inara S., Jorge Guzman, and Dan Wang. "High-skilled immigration enhances regional entrepreneurship." *Proceedings of the National Academy of Sciences* 121, no. 37 (2024): e2402001121.
Winters, John V. "Human capital externalities and employment differences across metropolitan areas of the USA." *Journal of Economic Geography* 13, no. 5 (2013): 799-822.
Winters, John. "Foreign and Native-Born STEM Graduates and Innovation Intensity in the United States." No. 8575. Institute of Labor Economics (IZA), 2014.
WIPO, World Intellectual Property Organization. "Global Innovation Index 2025: Ranking of World's Top 100 Innovation Clusters." Available at: https://www.wipo.int/documents/d/global-innovation-index/docs-en-2025-gii-2025-clusters-top100-ranking.pdf.