BRAIN FREEZE: HOW INTERNATIONAL STUDENT EXCLUSION WILL SHAPE THE STEM WORKFORCE AND ECONOMIC GROWTH IN THE UNITED STATES

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Abstract: America's longstanding strength in science and technology has depended heavily on international students, who make up nearly half of graduate enrollments in many STEM fields. Though universities function as the primary gateway for overseas talent to enter the US workforce, a suite of new federal policies seeks to sharply curtail this flow. This paper considers the potential scenario of a sustained, one-third reduction in foreign STEM graduates from US universities, and reviews the economic research literature on the expected ripple effects of such a decline. Using administrative and census data, we find the high-skilled STEM workforce would shrink, in this scenario, by over 6 percent overall and by over 11 percent at the PhD level. These estimates account conservatively for reactions by international students, scholars, and researchers who come to the US and by foreign STEM workers trained overseas. The best evidence from prior economic research implies cumulative effects on US innovation and productivity, reaching after a decade the present-day equivalent of $240–481 billion in lost economic product per year. Heavy restrictions on international students risk eroding America's innovative capacity and long-term prosperity.

I. Introduction

The United States has long benefited from an extraordinary competitive advantage: the ability to attract and educate many of the world's brightest minds (Bloom et al. 2019; Glennon 2024; Ganguli and MacGarvie 2025). Yet this advantage, built over decades of scientific leadership and institutional excellence, now faces unprecedented threats. It is crucial for America's continued technological and economic leadership to understand the value of international talent, the scale to which American universities act as a training ground for America's international talent especially in STEM, and the mounting risks to this system.

The US federal government is pursuing an intentional policy to reduce the number of international students at US universities, and to stop most of the students who remain from entering the US workforce after graduation. The US administration ordered Columbia University to "*take steps to decrease financial dependence on international student enrollment*" as a condition for fulfilling hundreds of millions of dollars in federal research contracts with the university.[1] That is, cutting the number of international students at US universities, in and of itself, is a goal of administration policy. The director of the federal agency that controls all adjudications for US immigration status has stated, "*We've got to do everything we can to really make it abundantly difficult—only in certain situations—for [foreign] students to think that they are just going to continue to live and work in the United States beyond the expiration of their [F-1 student] visa*".[2] That is, cutting the number of US-trained foreign graduates who enter the US workforce, in and of itself, is an explicit goal.

Student visa revocations, country bans, and major cuts to university funding via the National Science Foundation and National Institutes of Health have already affected international education in America. The administration took the further step of announcing a new, heavy tax of $100,000 on entry to the United States on an H-1B visa, on September 19, 2025.[3] All of these policies will without doubt deter many international students from taking the risk of studying in the United States at all. A recent headline in the globally influential *Economist* magazine warned: "Demand for American degrees is sinking".

At the time of writing, the administration has announced[4] several additional, upcoming steps that will directly impact all international students, scholars, and researchers on US campuses or intending to come to the US:

- Ending the 34-year-old practice of issuing student visa status valid through graduation and post-completion employment (so-called duration of status). Instead, the proposed policy would admit PhD students and others for only four years and face the uncertainty of applying for an extension of status during their program or whenever post-completion employment is sought.
- Terminating Optional Practical Training (OPT), the 78 year-old practice of issuing post-graduation work permits. OPT acts as a bridge from school to the US workforce.
- Prioritizing H-1B temporary work visa issuance for later career workers, with fewer slots available in the early career jobs for which fresh graduates can compete, despite a 73 year-old practice of allowing the visa classification to be readily available for early career professionals.

[1] Office of the President, "Our Resolution With the Federal Government", New York: Columbia University, July 20, 2025, paragraph 22, page 9.
[2] 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.
[3] White House, Presidential Proclamation: "Restriction on Entry of Certain Nonimmigrant Workers", September 19, 2025.
[4] Unified Regulatory Agenda of the Department of Homeland Security, Spring 2025 agenda issued September 2025.

The remaining question is how many international students will be lost, and how this will affect the United States.

In this paper, we consider one plausible scenario for the reduction of foreign STEM graduates, and consider the available evidence for its effects on the high-skill STEM workforce and economic growth of the United States. We draw out the implications of a hypothetical one-third reduction in the number of foreign graduates at US universities. We use a wide variety of data sources, from census data to surveys of university graduates to novel administrative data from the US Department of Homeland Security. We focus on STEM students, those receiving higher-education degrees in a Science, Technology, Engineering, or Mathematics discipline.[5]

We find that a reduction of one third in the annual flow of foreign STEM graduates at US universities would, sustained over time, reduce the number of employed high-skill STEM workers in the United States by 6.2%. This figure is for all degree levels collectively, with higher effects at higher levels of education. The same reduction in student flows results in an 11.4% decline in the number of PhD STEM workers employed in the United States. The best available estimates from the economic research literature imply that this reduction in the high-skill STEM workforce would reduce annual productivity growth in the US economy by 3 to 6% (not percentage points), cumulating to a loss of $220–439 billion *per year* after 10 years. We consider these impacts not as a prediction, but as an informative scenario. The true magnitude of future declines in international students cannot be known at the time of writing, but we expect the true decline—and thus the impacts—to be larger than the conservative scenario we consider should all of these policies be adopted and stay in effect.

In section II, we describe the policy history of the programs 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 US 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. Section VII estimates how the predicted effects on the STEM workforce would change the trajectory of US productivity and growth, finding major consequences for the US economy.

[5] 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').

II. Policy Context

International students earning US degrees are a critical input to the nation's STEM workforce and economy, because many international graduates from US universities, and most STEM grads, enter the US labor force in the short term and many remain in the country in the long term. The administrative data show that 54% of F-1 graduates get OPT, with most of the remaining 46% returning home after earning their degree. The initial retention numbers are higher among PhDs (67%) specifically and STEM grads generally, with 77.8% 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% on OPT, 13.6% changing status directly to H-1B from F-1 without OPT, .5% changing status to another nonimmigrant work visa category without OPT). The three biggest components of the front door pipeline are F-1 student enrollment, transitions from F-1 status to OPT work authorization, 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.

A. Duration of Status

Duration of status was introduced in 1978 to allow international students the ability to be admitted to the US 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."[6]

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

[6] 43 Fed. Reg. 32306 (July 28, 1978).

program – plus any period of post-completion OPT. DHS has published a proposed new regulation eliminating Duration of Status (D/S) admissions whereby international students no longer have the relative certainty their period of stay will cover their completion of a US degree and training programs.[7]

B. OPT recission

In August 1947,[8] 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, a program allowing employment authorization for international students after they have completed their degrees has continued, now through Department of Homeland Security (DHS) regulations governing F-1 nonimmigrants. In 2008, DHS announced the availability of a 17-month STEM OPT extension available for graduates of STEM degree programs. Because this rulemaking was invalidated in an August 2015 court decision, DHS undertook a new rulemaking that developed the final regulation[9] currently governing post-graduation employment authorization for STEM grads. International students earning US degrees in designated STEM degree programs[10] who have employers that complete a STEM OPT attestation,[11] are entitled to 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.[12]

C. H-1B restrictions

Established in the 1952 rewrite of the nation's immigration laws, the H-1 visa classification has existed for the last 73 years to allow 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. US 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."[13] When later that year Congress considered revisions to H-1 in the bill that became IMMACT90, 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 US workers are

[7] 90 Fed. Reg. 42070 (August 28, 2025)
[8] 12 Fed. Reg. 5355 (August 7, 1947).
[9] 81 Fed. Reg. 13040 (March 11, 2016).
[10] DHS STEM Designated Degree Program List (last updated July 22, 2024).
[11] I-983 Training Plan for STEM OPT Students.
[12] Spring 2025 Unified Agenda for DHS includes a new rule governing practical training (September 2025).
[13] 55 Fed. Reg. 2606 at 2608-2609 (January 26, 1990).

sometimes not available,"[14] and the enacted 1990 rehaul 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, and 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.[15]

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

III. Foreign STEM talent in the US workforce and universities

America's visas for foreign nationals to come to the US on the basis of their skills and employment operate largely 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, while our capacity to identify and attract fresh international talent remain 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 conduit through which high-skilled individuals first arrive in America. As one National Academies committee chair aptly observed in 2024, "The U.S. has a talent program. It's called graduate school."[16]

International education is a major U.S. export industry, contributing $54.8 billion to the US economy in 2024.[17] But the most important contribution of international students, scholars, and researchers who are attracted to US college campuses is as an engine of American innovation after entering the workforce. Consider that immigrants founded 44% of all "unicorn" billion-dollar startup companies from 1997–2019,[18] and immigrants or their children founded 46% of the "Fortune 500" largest firms in America.[19] Of the immigrants who founded high-potential startups backed by venture capital, 75% came to the United States as international students (Amornsiripanitch et al. 2023)—not on work visas, not on family visas, not by any other channel. 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

[14] H.R. Rep. 101-723 at p. 6747 (September 19, 1990).
[15] 90 Fed. Reg. 45986 (September 24, 2025) and Restriction on Entry of Certain Nonimmigrant Workers (September 19, 2025).
[16] Karen Fischer, "To remain scientifically competitive, the U.S. must take a coordinated national approach", *Latitudes* blog at the *Chronicle of Higher Education*, September 4, 2024.
[17] Bureau of Economic Analysis, "Table 2.1. U.S. Trade in Services, by Type of Service", US Dept. of Commerce. July 3, 2025 release.
[18] 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.
[19] American Immigration Council, "New American Fortune 500 in 2024", Sept. 9, 2024.

the most venture capital support, 70% have a co-founder that is an immigrant who first came to the US as an international student at a US university.[20]

The value proposition extends beyond individual achievements. International graduate students are a major source of the talent enabling American universities to maintain world-class research programs and American companies to develop and commercialize ideas. Immigrant inventors are responsible for 32% of aggregate innovation in the United States, in part by causing their non-immigrant colleagues to produce more of their own innovations (Jaravel et al. 2018; Bernstein et al. 2022). In engineering fields, 54% of workers with doctoral degrees originally came to the United States on student visas.

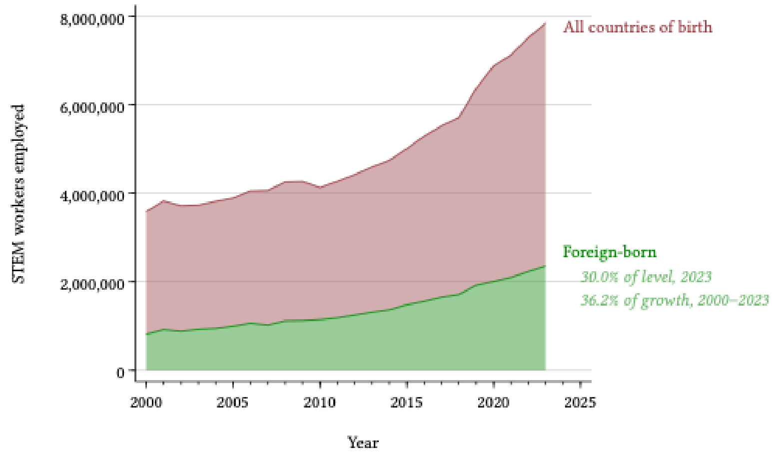
The US is more reliant on international talent in technical STEM fields and at higher levels of education. The foreign-born share of the population is approximately 16%, but foreign-born workers make up 30.0% of today's employed high-skill STEM workforce—that is, workers in Census-defined STEM occupations who hold a bachelor's degree or above. Growth in foreign-born workers accounts for 36.2% of all growth in the employed high-skill STEM workforce since the year 2000 (Figure 1a).[21] The figure shows a snapshot of the population in 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% of today's employed STEM workers whose highest degree is a master's. And the foreign-born constitute 50% 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, the role of foreign workers becomes dominant. Foreign-born workers make up 49.2% of today's employed STEM workers with a PhD degree. They constitute 62.2% of all growth in employed STEM workers with a PhD since the year 2000 (Figure 1c).

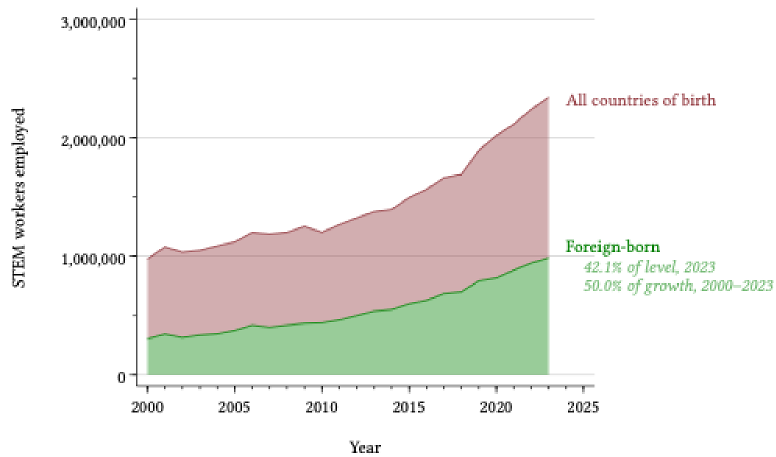
[20] Jeremy Neufeld and Lindsay Milliken, "Most of America's Top AI Companies Were Founded by Immigrants," Institute for Progress, April 16, 2025.
[21] Data from the American Community Survey 1-year public-use files (Ruggles et al. 2025). Includes only workers age 18–65, who have completed a bachelor's 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 NSF categorizes not as S&E occupations but as "S&E related". At the time of writing the 2023 microdata are the most recent available.

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

(a) All high-skill STEM



(b) Highest degree master's



(c) Highest degree PhD

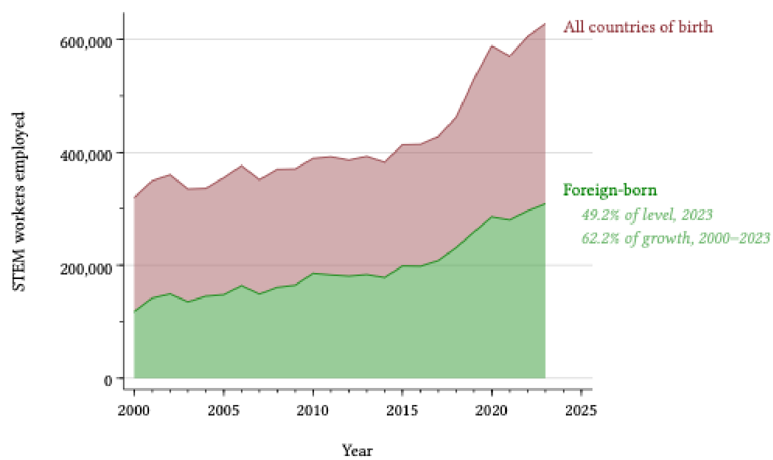
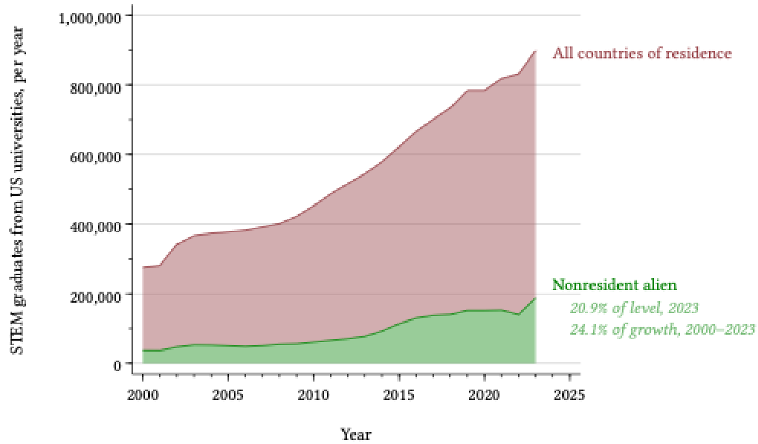
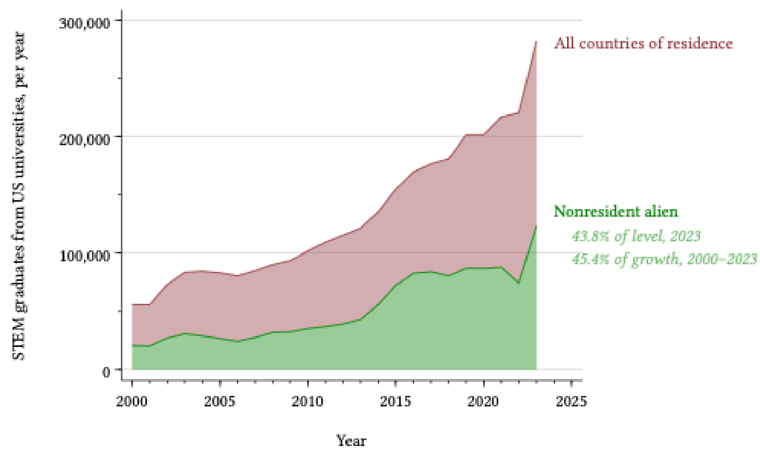


Figure 2: Immigrant fraction of new STEM graduates from US universities (flow), 2000–2023

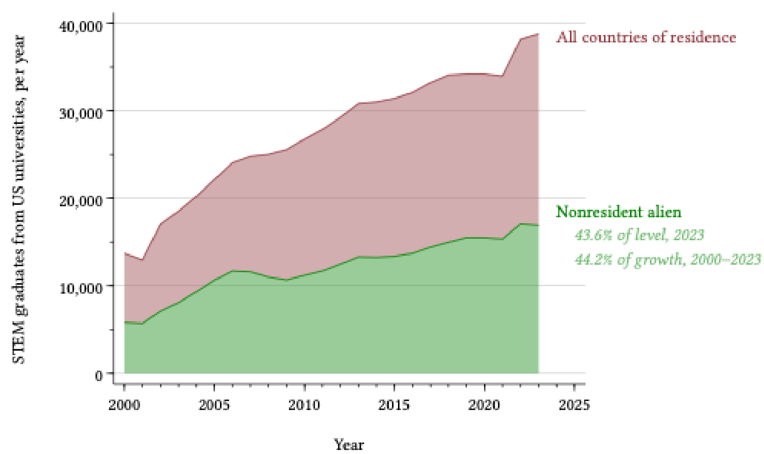
(a) All university degree completions



(b) Master's degree completions



(c) PhD degree completions



This high prevalence of immigrants in the high-skill STEM workforce has occurred alongside high rates of international-student graduation from STEM programs at US universities. Figure 2 shows the annual flow of new graduates from US universities in STEM fields.[22] In the most recent cohort of students in STEM fields completing any higher-education degree, 20.9% of graduates are nonresident aliens—people who are neither citizens nor permanent residents of the United States,[23] including people on student or training visas. Nonresident aliens make up 24.1% of 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% are nonresident aliens. And those international students make up 45.4% 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 PhD level. 43.6% of recent new PhD graduates in STEM are nonresident aliens, and those international students make up 44.2% of the rise in the annual flow of new STEM PhD graduates at US universities since the year 2000. 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* of international student prevalence among STEM graduates to the *growth*. For example, about 44% of the current flow of PhD STEM graduates are international students, and roughly the same percentage of *growth* in PhD STEM graduates over the past quarter century have been international students. This implies striking stability in the reliance of US higher education in STEM on foreign talent over the past generation. The economic importance and public salience of high-skill STEM workers has risen in recent years, as the demand for their work has boomed, but 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 US high-skill STEM workforce (Figure 1)? The effect is not straightforward. Many international graduates from US universities do not remain in the country in the long term, or even enter the US labor force in the short term. Those 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

[22] 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).

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

international graduates on the US high-skill STEM workforce, we must estimate the US 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 pathways overwhelmingly benefit individuals who have already established themselves within US borders. The vast majority of employment-based green cards—through a process called "adjustment of status"—go to people already working in the United States on temporary visas, particularly H-1B holders.

This distinction is crucial for understanding the immigration pipeline's architecture. While permanent residency offers invaluable benefits—freedom to change employers, launch businesses, enjoy greater career flexibility, and ultimately become a naturalized US citizen—it represents the culmination of an immigration journey. The beginning of that journey was 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 nonimmigrant visa programs. These temporary statuses form the actual gateway through which high-skilled workers enter the United States, though they come 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, admitting approximately 350,000 to 400,000 new, first time active international students annually in recent years, 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 workers to establish themselves professionally before transitioning to more permanent arrangements.

This program is a crucial pipeline in transitioning international graduates into the US 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-1Bs are used to retain those already here—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 are foreign students in degree-granting programs abroad who come to the US 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. But J-1 program participants are also teachers, professors, and researchers. The program is especially important in academic research, with nearly all postdoctoral researchers entering through this pathway. Most of these have historically been prevented from remaining in the US 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.[24] Because spouses of minor children of the so-called "principal" beneficiaries count toward the cap, less than half of the 120,120 green cards do not go to the selected high-skilled principals, although it must be noted that the spouses often are high-skilled themselves. The U.S. 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 nonimmigrant 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

[24] 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.

talented individuals often must leave despite eligibility, a job with 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 temporary visa numbers and available green cards means many high-skilled workers spend years—sometimes decades—in temporary status, despite having approved petitions confirming eligibility for classification as a lawful permanent resident. This uncertainty affects career decisions, family planning, and entrepreneurial ambitions.

Measuring inflows, outflows, and transitions

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 from abroad and the transition rate. We do this here with anonymized, full-universe administrative data from the Student and Exchange Visitor Information System (SEVIS) of the US Dept. of Homeland Security, obtained by a request under the Freedom of Information Act.

We define the long-term transition rate *between* any two immigration statuses as the share of a new cohort in one program who get status in the second program immediately after their participation in the first 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 immediately following F-1 OPT. The F-1 OPT to EB transition rate is the share of OPT participants who immediately get employment-based green cards 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 ever get EB permanent residency status, regardless of whether it is their *next* status.

A. Inflows

A new cohort within a visa program comprises both new arrivals and transitions. That is, the total number of new people entering a program within a given year is the sum of the new people entering the US from abroad and the people transitioning from another status. We will estimate transition rates in the next section, here we estimate new arrivals. More details on the methods can be found in the appendix.

Table 1: Estimates of new arrivals from abroad

	Total	STEM	PhD
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

- **F-1.** We estimate F-1 new arrivals using microdata from SEVIS. We estimate 226,000 new F-1 students graduate each year.[25] Of those, 104,000 graduate in STEM fields and 23,000 graduate with PhDs.
- **J-1**. We estimate the arrival of high-skilled J-1 new arrivals using SEVIS data on new J-1s going to visitors by exchange category. From 2014-2023, there were approximately 100,000 high-skilled J-1 visitors entering the US each year.[26] We also have microdata on degree fields for categories representing over half of the 100,000 high-skilled J-1 visitors. From this, we can estimate that the share of new high-skilled J-1s who have STEM degrees is 31%, suggesting an inflow of 31,000 high-skilled J-1 workers in STEM fields. Assuming that PhDs use the research scholar, specialist, and student doctorate categories, we find that there are 29,000 newly arriving PhDs each year on the J-1 program.
- **H-1B.** We estimate H-1B new arrivals using information from DHS's H-1B Characteristics Reports, which specifies whether initial H-1Bs request changes of status or consular processing. Given that some people already with status nevertheless pursue consular processing (we assume it is 6% of total consular processing), we estimate 61,000 new H-1B arrivals each year. Of those, we estimate that 79%, or 48,000, are for STEM workers (inferred from STEM occupations) and 14% or 9,000 are PhDs.
- **EB-1, EB-2, and EB-3**. We estimate aggregate EB-1, EB-2, and EB-3 new arrivals using data from DHS's statistical yearbook. 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 are PhDs.

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.

B. Transitions

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

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[25] 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.
[26] 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.

The first major transition we consider is F-1 to F-1 OPT transitions. OPT represents the first opportunity for post-graduation work authorization and represents a major pipeline for graduates into the US workforce. SEVIS data reports directly that over the last five years of data available (2018–2022), 54% of F-1 graduates got OPT. That number is higher among STEM graduates (64%) and among PhDs (67%).

The next major transition is F-1 to H-1B. Some F-1 graduates get an H-1B immediately, without OPT. SEVIS data suggests that bout 9% of a graduating class manages to change status to an H-1B without OPT. That number is higher still for STEM graduates (14%) and PhDs (11%). However, much more common is transitioning to an H-1B from OPT. SEVIS data show 29% of OPT participants in all fields get an H-1B (15.4% of all graduates). Among PhDs, the share is 41% (28% of all graduates). Given STEM OPT's longer duration, it is not surprising that a greater share of STEM grads (52% of OPT participants and 33% of all graduates) change status to an H-1B after OPT.[27]

Next, we consider the H-1B to EB transition rate. H-1Bs are indefinitely renewable for those with an approved EB petition, so even someone who waits decades may eventually get an EB. This likely means there is significant deviation between short-term and long-term transition rates and between countries. We take the transition rate of H-1B into EB-2 (non-National Interest Waiver) and EB-3 from FY 2024 PERM data, and apply this to *principal* visa recipients (without spouses/dependents) adjusting status to EB-1 *excluding* intracompany transfers, and all principals adjusting status to EB-2 and EB-3. This implies that about 41% of H-1Bs and 4.8% of other nonimmigrant work visas (E-3, H-1B1, O-1, and TN) transition to EB-1,2,3.[28] These are the figures we assume in constructing Table 2.

For long-term retention on H-1B visas, we estimate the number of long-term extenders by comparing H-1B petition approvals for continuing employment to the number of approved petitions for initial employment three years prior.[29] Our method is as follows. The number of

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[27] These rates are those 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% higher than the change-of-status rates.

[28] We first count the total adjustments of status to EB green card each year, omitting adjustment 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 nonimmigrant work visas in the same proportion as the adjustments recorded publicly in the PERM data, which are available for the large majority 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 extending stay on an H-1B visa past six years with an approved immigrant visa petition, many of whom may later adjust to EB green card.

[29] The number of H-1B petitions for initial employment is primarily governed by statutory caps, so is relatively stable from year to year. Since the very large 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-

petitions for continuing employment is, on average, 1.513 times the number of petitions for initial employment three years earlier. The number of petitions for continuing employment includes both standard continuation (first-time renewal of the H-1B) and extended renewals for those who have already renewed once, and who have an approved petition for an EB green card, but who are waiting for an EB green card to become available. But it would overestimate the transition rate into 'long term' (>6 years) H-1B status to estimate it as 51.3%, because that number 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% of H-1B holders reaching the end of the standard six-year period of single-renewal H-1B validity continue renewing past 6 years with an approved EB petition, an approximate transition rate that is consistent with the observation that the number of continuing-employment H-1B petition approvals each year is 51.3% 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 adjusting to an immigrant visa via marriage, other family, or the Diversity Visa lottery; asylum; departure from the US 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 US; or an EB visa as a new arrival, not adjustment of status). The 'front door' includes only students who change nonimmigrant visa status and then adjust status to permanent resident directly, without extended absence from the US.

A small number of J-1 exchange visitors, above and beyond 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. USCIS reports this information directly. From 2019-2023, USCIS reports the average J-1 to H-1B transition rate was 6%. The J-1 to EB-2 (non-National Interest Waiver) and EB-3 transition rate in DOL PERM data is only 0.5%. We take the J-1 to EB transition rate to be 1%.

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, as an estimate of the fraction of workers receiving H-1B visas for initial employment who extend their stay past six years.

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		PhD	
	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 (nonimmigrant 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 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 are 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. 'PhD' means all completions of doctoral degrees by F-1 visa holders in all fields, not just STEM. In the table, "%" means percentage of the original F-1 graduation cohort in the first row that eventually makes each transition. Numbers are averages over the years 2018–2022. "Other" nonimmigrant work visas are 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.

Pathways to retention

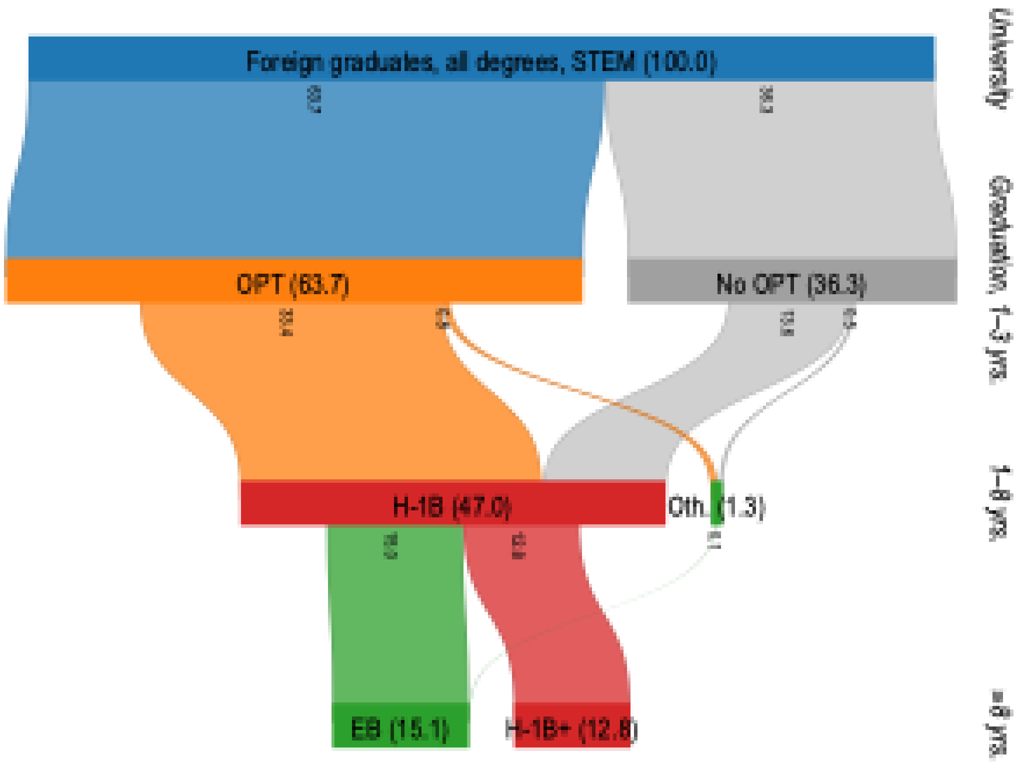
The 'front door' pipeline to long-term retention from Table 2 is shown graphically in Figure 3. It contains four rows or levels, proceeding forward in time from top to bottom. In the topmost (blue) level, 100 international students on F-1 visas complete a STEM degree at a US university.

The second (orange) level shows how many transition to employment under Optional Practical Training for the first 1–3 years after graduation. The third (red) level shows changes-of-status for those F-1 graduates directly to a nonimmigrant work visa. The most important of these is the H-1B visa. "Other" includes all other meaningful nonimmigrant work visas.[30]

[30] E-3, H-1B1, O-1, TN, and a tiny fraction that pass directly from F-1 to EB-1,2,3

Finally, the lowest (green and red) level represents long-term retention in the US workforce, by 10 years or more. This can occur primarily through adjustment of status from a nonimmigrant visa to an employment-based immigrant visa, or by long-term continuing employment on an H-1B visa for nationals of countries with an immigrant visa backlog.[31] 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: 'Front door' pipeline, foreign STEM graduates, all degrees



Data from Table 2. The percentages at each level of Figure 3 are 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 (nonimmigrant work visa) are estimated from the average rate of changes of status recorded in SEVIS between 2018 and 2022.

Figure 3 implies that 77.8% of international student STEM graduates from US universities, at all degree levels, enter the US workforce immediately after graduation via this 'front door' pathway.

[31] 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 indefinitely in the United States as long as they have an approved immigrant visa petition.

This includes 63.7% on OPT, 13.6% who change status directly from F-1 to H-1B without OPT, and 0.5% who change to another nonimmigrant 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% of graduates remain in the US high-skill STEM workforce 8 years later via the 'front door' pathway.

How many remain long-term by other pathways? We can compare those estimates to overall retention by independent means. We do so in Figure 4 by comparing data on the population of foreign graduates of US universities in 2023, by year of graduation, to the number of foreign-student graduates from each year. Any difference between those numbers is attrition of some kind, of which departure from the country is the most important. But to control for all other forms of attrition (mortality, recall) we estimate foreign-graduate attrition relative to attrition for US students (citizens and residents).[32]

This method, which should capture retention via the 'front door' and all other 'doors', implies that eight years after graduation, about 38% of nonresident alien STEM graduates—at all degree levels, bachelor's and above—remain in the United States. Comparing this to the retention rate estimated for the 'front door' pathway above implies that 74% 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.

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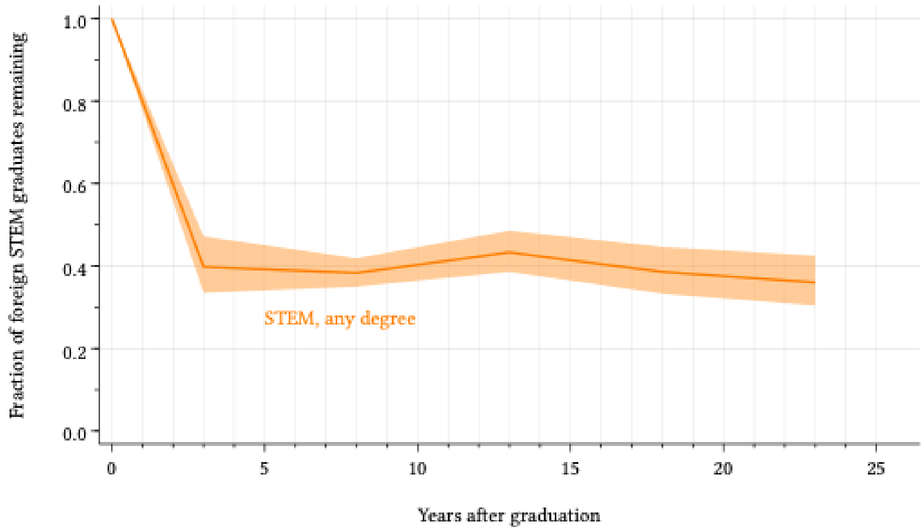
[32] Data from the National Survey of College Graduates (NSCG) and NCES IPEDS. The NSCG survey in 2023 includes the year of graduation for each person who graduated from a US university but arrived as a foreign student, by degree and field. This allows estimation of the number of people who (for example) graduated from a US university with a STEM degree in the year 2015 after arriving as a foreign student, and were (by definition) still present in the US in 2023 in order 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 US retention, foreign STEM graduates, all degrees

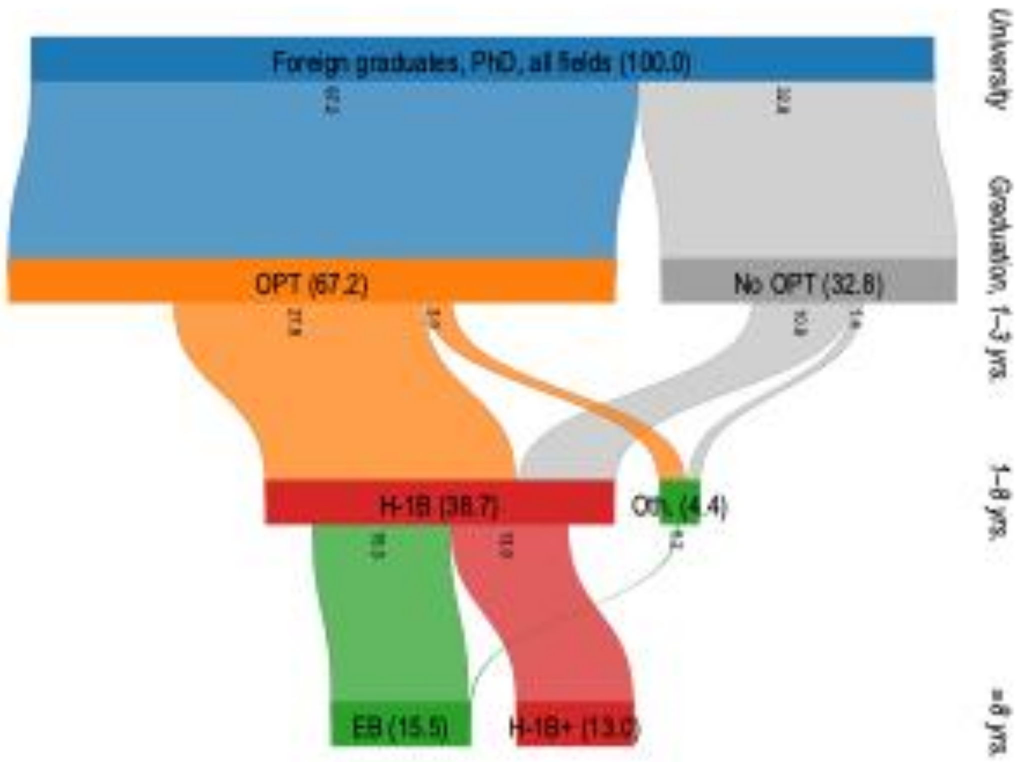


Data from the National Survey of College Graduates and IPEDS. The figure shows the estimated mean retention rate of graduation cohorts grouped into five-year intervals (the average retention rate over 1–5 years from graduation is plotted at the middle of the interval, 3 years; the average retention rate over 6–10 years is plotted at the middle of the interval, 8 years; and so on). The shaded area shows the interval of 95% statistical confidence on the estimate of the mean.

STEM PhD 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 for foreign PhD graduates of US universities on F-1 visas. The figure includes all PhD awards, both in STEM and non-STEM fields. The short-term retention rate is 79.4%. This includes 67.2% entering the US workforce immediately after graduation on OPT, 10.8% changing status directly from F-1 to H-1B without OPT, and 1.4% changing to some other work visa (such as O-1) without OPT. But the long term retention rate of PhD graduates by the 'front door' path, past 8 years after graduation, is limited: just 28.5%.

Figure 5: 'Front door' pipeline, foreign PhD graduates only, STEM and non-STEM

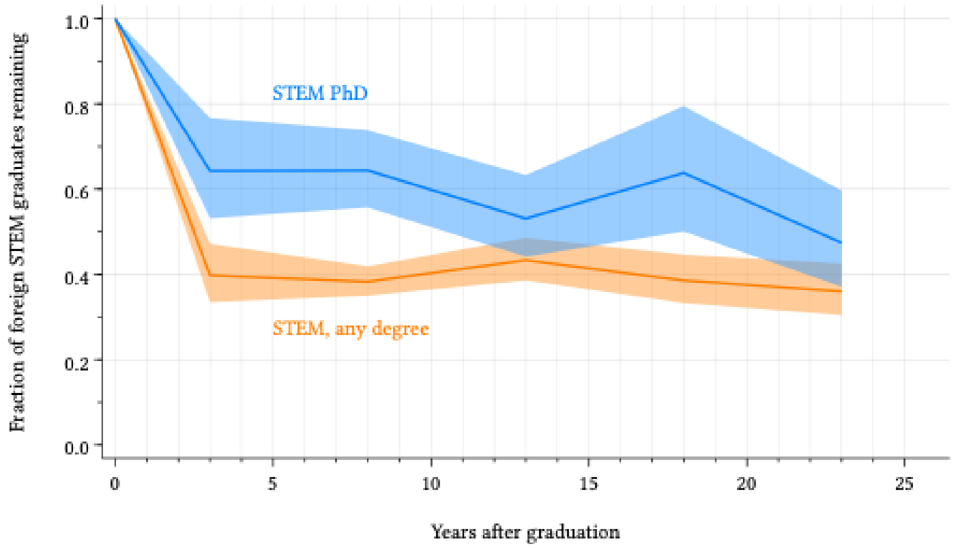


How many PhD graduates use other pathways to remain in the US? Figure 6 repeats the overall retention analysis of Figure 4, for STEM PhD graduates specifically (and juxtaposes it with the retention rate of all STEM degrees collectively from Figure 4, for reference). This analysis implies a retention rate, 8 years after STEM PhD graduation, of 60–65%. This suggests that a substantial majority of STEM PhD 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 temporary departure from the US 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 PhD graduates is marriage to a US 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.

We note that the US retention rate of foreign STEM PhD graduates in Figure 6 is slightly below other published estimates. We estimate a 10-year retention rate of roughly 65% in 2023, matching the estimate by NSB from 2021 (NSB 2024, 13).[33]

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

Figure 6: Rate of US retention, foreign STEM graduates, PhD only vs. all degrees



V. Effects of a reduction in international students on the STEM workforce

We use the above retention data to model mechanistically the short- and long-term impacts on the US STEM workforce of two different policy scenarios: A decline of one third in international student enrollment, and the elimination of OPT.

Policy experiment: Reduce foreign STEM graduates from US universities by one third

The first scenario examines a one third decline in the enrollment of international students, which we think is a conservative estimate of the likely effect of ending Duration of Status, rescinding all OPT, and adopting an experience-based H-1B prioritization.

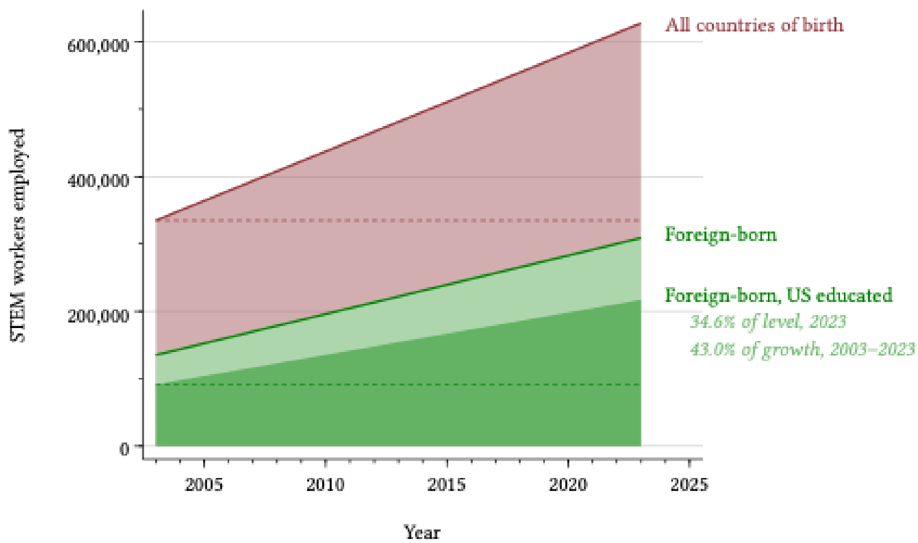
International students make decisions about studying in the United States based on expected returns relative to alternative destinations. Policies like ending Duration of Status (D/S) increase uncertainty by raising the risk of disruption mid-degree, lowering the expected probability of program completion. Eliminating Optional Practical Training (OPT) removes the single largest channel for recouping education costs, gaining career experience, and transitioning into the US workforce long-term, significantly reducing the perceived benefit of a U.S. education. Finally, prioritizing H-1Bs by seniority diminishes the probability that new graduates can transition into long-term employment in the United States, since they are disproportionately concentrated at entry-level wage levels.[34] Each change alters the benefit-cost calculation at the application stage, deterring enrollment. In economic terms, these policies simultaneously raise the risk of an inability to transition 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.

Survey evidence supports this mechanism. In August and September 2025, two surveys asked current students and postdocs and of 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 professional science societies, led by the American Physical Society and the National Postdoctoral Association. 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 sending countries. Among prospective students to the United States, the self-reported likelihood of enrolling in U.S. programs falls by 16 percentage points with the loss of D/S (from 67% to 57%), by 29 points if OPT were rescinded (to 48%), and by 6 points if H-1B allocation were shifted to wage-level prioritization. For current students, retrospective counterfactuals are even starker: 49% said they would not have enrolled without D/S, 54% without OPT, and 53% if H-1Bs were seniority-based.[35] Taken together, these findings indicate that the three policies each exert strong independent deterrent effects. A combined decline of roughly one-third in enrollment therefore represents a cautious estimate that surveys suggest could be substantially larger.

The long-term impact of a reduction in international student enrollment is estimated assuming that retention follows historical patterns. For example, in the most recent data available, 34.6% of the high-skill STEM workforce with a PhD degree is made up by workers who are foreign-born *and* received their STEM PhD degree in the United States (Figure 7).[36] If the number of foreign STEM PhD graduates during the entire period 2003-2023 had been reduced by one third, year after year on a continuing bases—but the retention of any given graduate had remained the same—then the number of foreign-born, US-graduate STEM workers in the United States by the end of that period would be mechanically reduced by one third of 34.6 percentage points of the overall number, or 11.5% of the current stock of high-skill STEM workers with a PhD.

[34] 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%. A large fee would only exacerbate this effect.
[35] Institute for Progress and NAFSA: Association of International Educators, "Surveys on International Talent Pipelines," September 15, 2025.
[36] 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 rather than 2000 because 2003 is the year in which the National Survey of College Graduates was conducted that is closest to 2000.

Figure 7: Immigrant prevalence US PhD STEM workers (stock), 2000 versus 2023



We show the results of applying the same method to various degree categories in Table 1. The long-term impact of a continuing, year-after-year decline by one-third in the number of international STEM graduates over the past two decades mechanically implies a long-term reduction in the *total* number of employed high-skill STEM workers of 11.5% today, for PhD graduates specifically. It implies a 14.3% reduction in the *increase* of PhD STEM workers over the past two decades. Across all degrees collectively (bachelor's or higher), it implies a mechanical reduction of 6.2% in the number of employed STEM graduate workers today, and a 7.6% reduction to the increase in employed STEM workers over the past two decades. For workers with a master's as their highest degree, the same ongoing reduction in international graduates implies a long-term mechanical reduction of 9.4% in the overall number of employed STEM workers with a master's as their highest degree.

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

	Total employed		Foreign-born, US 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 PhD	334,926	627,638	91,477	217,226	−11.5%	−14.3%

An alternative way to conceptualize the workforce impact of a one-third reduction in international student graduates is the immediate, short-term impact on US workforce entry by a single cohort of newly-graduated workers. The first stage of the graduation-to-workforce pathway in Figure 3 implies that 77.8% of new foreign STEM graduates from US universities, across all degree levels, directly enter the US workforce the year after graduation via OPT, H-1B, or a handful of minor nonimmigrant visa categories. Because foreign graduates are 20.9% 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 $1/3 \times 0.209 \times 0.778 = 5.4\%$.

Table 2 shows this impact for various degree levels. The same mechanical impact for STEM master's graduates implies a short-run reduction of 11.0% in the number of newly-graduated workers. For STEM PhD graduates, this short-term reduction is 11.5%.

Table 2: Short term impact scenario, 1/3 reduction in foreign STEM graduates

	Foreign graduates, 2023	Total US & for. graduates, 2023	US retention of foreign grads, yr 1	Short-term impact of 1/3 reduction
STEM, all degrees	187,416	897,938	0.778	–5.4%
STEM master's	123,651	282,436	0.756	–11.0%
STEM PhD	16,905	38,794	0.794	–11.5%

Policy experiment: Eliminate Optional Practical Training

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 or other statuses on their behalf 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 and forces all graduates to jump straight from F-1 to another status or, far more likely, to depart. Because the H-1B cap is saturated and adjudications occur months after graduation, the large majority of students who would have used OPT as a holding pattern while waiting on the lottery would now face a forced exit point instead of a gateway.

Figure 3 shows that 63.7% of new foreign STEM graduates on F-1 visas over the last five years pass through OPT, with most of those changing to another nonimmigrant employment visa (34.2% of the original graduates, or 53.7% of those who got OPT), and most of *those* staying long term. In other words, ***OPT is by far the largest part of the 'front door' pipeline that connects foreign STEM***

graduates to the US workforce, the pipeline that the large majority of those graduates (3 out of 4) rely on in order to remain in the country. Terminating OPT would cut off this conduit.

We can estimate the short- and long-term impacts quantitatively by the following method. Figure 3 shows that 14.1% of new foreign STEM graduates *without* OPT are able to continue in the front-door pipeline. Thus, although OPT facilitates that transition, even in the absence of OPT some graduates will be able to continue down the 'front door' pathway. Conservatively, suppose that terminating OPT cuts by half the number of students that would otherwise have continued in the pipeline via OPT. This scenario would imply that, even without OPT, the number of new STEM graduates entering the workforce would be 31.2%.[37] Comparing this to the 48.3% of STEM graduates across all degree levels who reach the third level of Figure 3 currently, this scenario implies a reduction of 35% in the number of foreign STEM graduates retained in the US workforce in the long term. This in turn, revisiting the method used in Table 1, implies a long-term reduction of 6–7% in the overall number of high-skill STEM workers in the US economy in the long term. This reduction would be larger if fewer than half of the new graduates who would have found a work visa sponsor and an available visa while on OPT are able to find these in the absence of OPT.

The short-term impact of OPT termination in this scenario would be larger. Immediately after graduation, with OPT as an option, 77.8% of STEM graduates at all degree levels enter the US workforce. In the absence of OPT, under the same assumption above that half of those who found a work visa while on OPT would have been able to find one in the absence of OPT, the immediate post-graduation workforce entry of the average STEM graduate would be, again, 31.2%.[38] That is, the number of new foreign STEM graduates entering the workforce immediately after graduation would fall by 59.9%. Because foreign graduates are 20.9% of all new STEM graduates (Figure 2), this would imply a mechanical reduction of 12.5% in the *total* number of new STEM graduates (foreign, resident, or native) entering the US workforce directly after graduation. Again, this shock would be larger if the fraction of workers who currently find a work visa via OPT, but would still be able to find one without OPT, is less than half.

There are at least two other important mechanisms by which eliminating OPT is expected to affect the high-skilled workforce which we think are important but will leave for future research. First, there is likely substitution within capped immigration categories. H-1B slots currently expected to be filled by F-1s may be filled with new people from abroad, 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 US 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.

[37] Because 14.1% enter the pipeline without OPT currently, and the 63.7% who get OPT are assumed to proceed in the pipeline at half the current rate, thus 14.1 + (63.7 × (0.5 × (34.2/63.7))) = 31.2.
[38] (34.2 × 0.5) + 14.1.

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 reaction, in the face of a large reduction in international graduates from US universities, of immigration by foreign-educated foreign workers. A second involves the possible reaction by US students. Here we consider existing evidence on each.

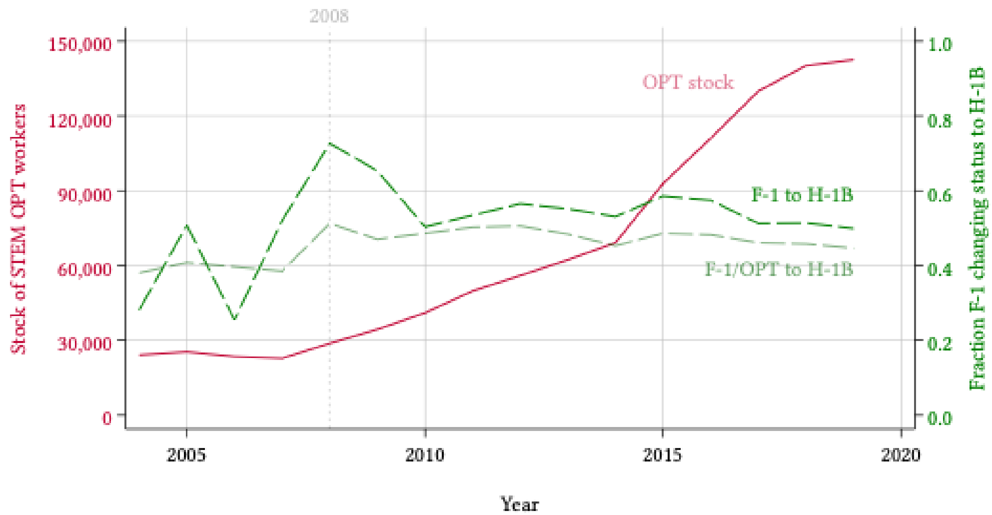
Substitution by foreign-trained STEM workers

If a portion of US-educated foreign workers disappear from the US 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 with reallocations of unused family-reunification visas from prior years. But broadly speaking, there are binding constraints on the supply of H-1B nonimmigrant employment visas and Employment-Based immigrant visas for permanent residency for the large majority of foreign workers, whether educated in the United States or not. Thus it is possible in principle that reductions in the number of US-trained foreign STEM workers receiving these visas could cause an offsetting increase in the number of foreign-trained STEM workers receiving them.

But 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.[39] 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 US-educated foreign STEM workers studying in the United States and 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.

[39] 73 Fed. Reg. 18944 (April 8, 2008).

Figure 8: STEM graduates on OPT and transitions to H-1B, pre-COVID



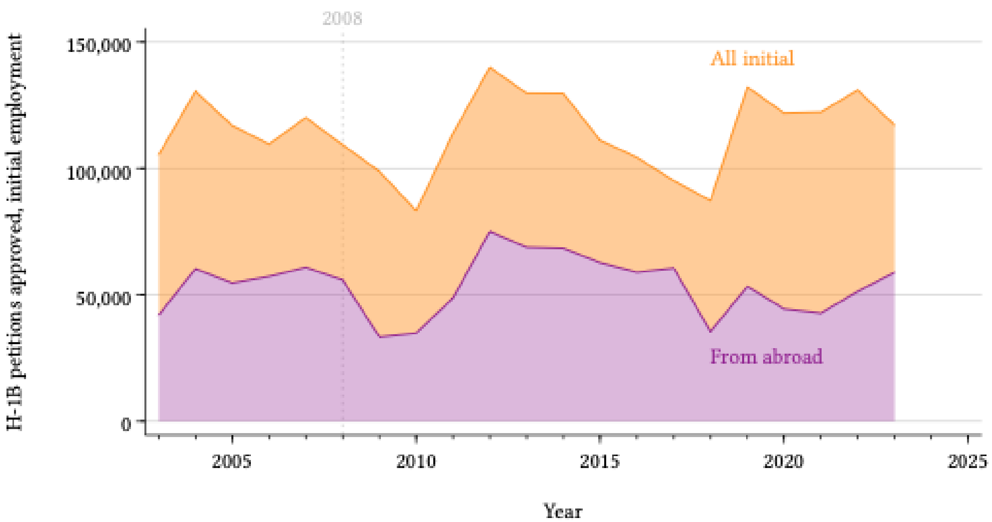
Data from DHS SEVIS obtained by request under the Freedom of Information Act. The fraction changing to H-1B means the fraction that ever changed status from F-1 to H-1B in any subsequent year, not instantaneous transition rates.

But nothing of this kind occurred. The SEVIS data discussed above 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 on average in the pre-COVID years 2010–2019, when far more STEM OPT workers were seeking H-1B visas, 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 a fixed supply of H-1B visas accessible to US-educated foreign STEM workers.

Nor did the very large expansion of US-educated foreign STEM graduates seeking H-1B visas result in a decline in the number of arrivals of new H-1B workers from abroad. Figure 9 shows the number of H-1B workers each year with an approved petition for initial employment, in each year, in orange ("All initial"). It shows the portion who did not change status in the United States but received their H-1B through consular processing overseas, in purple ("From abroad"). The latter is a good indicator of the number of H-1B workers arriving from abroad after training abroad, rather than starting employment in the United States after training in the United States. Figure 9 reveals dips in these arrivals as the Great Recession hit in 2009, and amidst tightened H-1B restrictions by the first Trump administration in 2018.

But there is little sign that foreign-educated foreign workers were crowded out. The number of arrivals of these primarily foreign-trained H-1B workers was not systematically *lower* in the years 2011–2017, when the number of OPT STEM workers in the United States was high (Figure 8), compared to the years before 2008. If the greatly expanded supply of US-educated OPT workers were competing for a fixed supply of H-1B visas, we would expect that large expansion in demand for H-1B visas to cause an important 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.

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 US Citizenship and Immigration Services, *Characteristics of H-1B Specialty Occupation Workers, Report to Congress*, US Dept. of Homeland Security, various years.

Together, Figures 8 and 9 are inconsistent with the idea that the large expansion of foreign graduates entering the US 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 US 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. But this indirect evidence is not definitive and should be the subject of further inquiry.

Substitution by US natives and residents

Another possibility would, in principle, complicate the interpretation of the impact scenarios above. It is possible in principle that a large reduction in the supply of US-educated foreign STEM workers cause an offsetting increase in the supply of STEM graduates among US natives and residents. This can be tested empirically: If declines in the supply of international students tend to 'crowd in' US students, we should observe rises in the supply of international students to 'crowd out' US students.

A large research literature has investigated this possibility. It has found no evidence that international students systematically crowd out US students at the national level (Borjas 2007, Jackson 2015, Shen 2016). Ransom and Winters (2021) find the same for STEM students in particular in the 1990s, on average across all Americans, confirmed by Orrenius and Zavodny (2015), in spite of some heterogeneous effects for specific subgroups of the population.

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 native students (Shih 2017, Bound et al. 2020). Increases in the foreign STEM workforce of US cities leads to greater specialization of native workers in socially-intensive tasks within occupations, but does not reduce their supply of STEM tasks (Lin 2019). In other words, the prevalence of foreign STEM workers, including the US-trained, causes US workers to adjust the task content of occupations 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 *increase* in the wages of exposed native STEM workers overall (Demirci 2020, *Appendix*)—that is, it increased the incentive of US students to study STEM fields.

A limited set of studies have 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 by design (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. But 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 US higher education in STEM has skyrocketed along with demand in recent decades. Findings that slots at elite colleges are fixed in the short run is not informative about whether slots in STEM training are fixed at the national level, even in the short run, and are thus 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 US universities are competing with natives for a fixed number of classroom slots before they graduate, or competing with foreign-education foreign workers for a fixed number of work permits after they graduate—to first order. Beyond this, the section to follow will discuss evidence in the literature of a range of effects of foreign students on US productivity, innovation, entrepreneurship, and economic growth. If foreign STEM students were anywhere near perfect substitutes for native STEM students, we would not observe substantial effects of that kind. In such a scenario, foreign STEM students and workers would simply take the place of natives, leaving economic outcomes unchanged. As we discuss below, the evidence on broader economic impacts of foreign STEM students and workers is inconsistent with that conjecture. Increases in the supply of foreign STEM students, at the national level, act as complements for native students at least as much as they are substitutes. This too suggests that the simple, mechanical impact scenarios in the preceding sections—which abstract from the possibility that slashing foreign STEM graduations at US universities would substantially crowd in native STEM enrollment—are nevertheless informative about real-world impacts.

VII. Effects on US growth and productivity

The research literature contains very extensive evidence—consensus would not be too strong a word—that high-skill immigration causes large increases in productivity and economic growth in the United States. These effects are largest for immigrants with STEM training. The increase in US city-level productivity caused by inflows of foreign STEM workers from 1990 to 2010 is sufficient in magnitude to explain between 30 and 50% 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).

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 master's graduates driven by an unrelated *force majeure* cause more entrepreneurship in exposed regions, including by US natives (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 natives (Hunt 2011); foreign STEM PhD students report greater preference for entrepreneurship than their US native colleagues (Roach et al. 2019). Historical increases in barriers against skilled immigration caused reduced scientific productivity in the US as a whole (Moser et al. 2014, 2025). Increases in foreign STEM PhD student inflows to the United States driven by unrelated shocks overseas cause increased innovation and discovery in US academic departments (Stuen et al. 2012, Gaulé and Piacentini 2013).

It is generally recognized that many highly educated immigrants increase innovation with their own new ideas. But beyond this, high-skill immigrants cause innovation *by natives*. Beine et al. (2024) find that roughly one third of the positive effect of foreign master's graduates on US entrepreneurship arises from business creates by natives. Bernstein et al. (2022) find that immigrant inventors cause their native colleagues to patent more new ideas. 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 US cities (Kerr and Lincoln 2010, Winters 2014), increased entrepreneurship in US regions (Tareque et al. 2024), and at US firms, increased employment of high-skill native workers (Kerr et al. 2015), 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). All of this evidence points to a comparative advantage in STEM occupations for highly educated foreign workers, for reasons including language ability and the tacit knowledge of natives for socially-intensive tasks at work (Hanson and Slaughter 2017). This specialization is an emergent feature of groups that include both immigrants and natives, rather than a trait embodied in one or the other.

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 native workers without a high school degree—the same positive effects on less-skilled workers that arise from concentrations of high-skill workers in general (Winters 2013).

This literature collectively suggests that a substantial reduction in the supply of foreign talent to the US workforce will have large, negative, 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 estimate the elasticity of annual growth in Total Factor Productivity (TFP) to the share of the workforce comprising high-skill foreign STEM workers. They estimate an increase of 0.27–0.54 percentage points in annual TFP growth caused by each percentage point increase in high-skill immigrant STEM workers as a fraction of the overall labor force.

We can use this estimate to consider the overall economic growth impact implied by the impact scenarios from Table 1. There, an ongoing reduction of one third in the number of foreign STEM graduates from US universities reduces the supply of high-skill STEM workers in the United States by 6.2%. Because the 8 million high-skill STEM workers overall represent 4.7% of the US labor force, the 6.2% reduction in high-skill foreign STEM workers equates to a 0.29 percentage-point change in high-skill STEM workers as a fraction of the labor force.

The Peri et al. elasticity thus implies a reduction of 0.079–0.158 percentage points in annual TFP growth, arising from ongoing reduction of one third in the number of high skill foreign graduates from US universities. This is comparable in magnitude to the independent estimates of Hunt and Gauthier-Loiselle (2010), which together with the effects jointly implied by Kerr and Lincoln (2010) and Peri et al. (2015), represent the best available evidence on the macroeconomic effects of high-skill foreign STEM workers' presence in the economy.

This is a very large impact, which cumulates over time. Over a ten-year period, lost productivity growth of 0.079–0.158 percentage points each year causes GDP at the end of that decade to be 0.79 to 1.57 percent smaller than it otherwise would have been. 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 US economy would suffer from the *disappearance* of the entire economy of South Carolina (about 1.2% of national GDP), or Utah (1.0% of national GDP), or Wisconsin (1.5% of national GDP).

If such a loss occurred today, amid the United States's $30.4 trillion economy, it would be valued at $240–481 billion.[40] That is, this would be the loss to today's US economy if the stock of high-skill foreign STEM workers had been 6.2% lower, in each of the past 10 years, than it actually was—the loss that would have arisen from a longtime reduction of one third in the number of foreign STEM students graduating from US universities.

VIII. Conclusion

The challenges facing America's high-skill immigration system will be extensive with consequences far beyond elite coastal enclaves. 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 and Boston 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, or Madison, Wisconsin, have built innovation economies around universities that attract significant international student populations.

The Global Innovation Index identifies 23 U.S. clusters among the world's top 100 science and technology clusters, demonstrating the geographic diversity of American innovation. These clusters span from San Jose-San Francisco and Boston-Cambridge to Austin, Cincinnati, Denver-Boulder, Pittsburgh, and Raleigh-Durham. Each relies heavily on the international student pipeline to maintain their competitive edge. About 23% 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. 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 PhDs, including migration to other regions. The Northeast does even worse at retention. Meanwhile, the West Coast does best of all, 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 regional levels. Improved tracking would enable evidence-based policymaking. Our estimates are a start based on information that exists, but better data would allow more accurate and granular estimates of flows (and their characteristics) throughout the entire immigration system.

Complete administrative data detailing status-to-status transition rates should be made regularly available. Detailed surveys of new immigrants like the New Immigrant Survey. Existing surveys like the NCSES surveys that provide rich information on STEM graduates and workforce need to be

[40] In the most recent data available at the time of writing, the GDP of the United States in fiscal 2025Q2 was $30.35 trillion: U.S. 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.

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.

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, other countries modernize their systems and actively recruit the talent America is losing.

US universities are the primary conduit for attracting high-skilled STEM talent to the United States. 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.

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