BRAIN FREEZE: HOW RESTRICTIONS ON INTERNATIONAL STUDENTS SHAPE THE STEM WORKFORCE AND ECONOMIC GROWTH IN THE UNITED STATES

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This paper was commissioned 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 Summit planning committee or the National Academies of Sciences, Engineering, and Medicine.

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Introduction

The United States has long benefited from an extraordinary competitive advantage: the ability to attract and educate the world's brightest minds. Yet this advantage, built over decades of scientific leadership and institutional excellence, now faces unprecedented threats. The United States' continued technological and economic leadership depends on a universal understanding of the value of international talent as well as the scale of its presence in our universities. There are mounting risks to the current system.

International students represent the primary source of new high-skilled talent to the United States, making universities crucial intermediaries in the immigration system. If current policy measures to deter international students from coming to the United States succeed, they will leave a large and lasting hole in the high-skill STEM workforce. The U.S. federal government is currently enacting a wave of policies that will likely severely restrict the number of international students at U.S. universities. Such policies include revoking the ability of Harvard University to enroll any international students at all and threatening to do the same at other universities, including the University of Virginia. Other policies involve canceling student visas *en masse*, announcing a program to "aggressively revoke" visas for Chinese students, imposing a blanket ban on the issuance of any student visas to individuals hailing from 19 countries under a new Travel Ban, and detaining international students by armed agents for unknown reasons.

At the time of writing several additional, upcoming steps have been announced: plans to terminate Optional Practical Training, a post-graduation work permit and bridge to the U.S. workforce that increases the value of a U.S. degree for many international students; plans to end the 46 year-old practice of issuing student visas that are valid until graduation (*duration of status*) and instead requiring Ph.D. students and others to face the uncertainty of applying for a new visa after four years; and plans to limit H-1B temporary work visa issuance for entry-level, lower-paying jobs that fresh graduates can compete for. These policies are highly likely to deter many international students from taking the risk of studying in the United States at all.

In this paper, we explore the potential impacts of policy changes such as these, including how many international students might be lost and how this may affect the United States. 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 U.S. Department of Homeland Security (DHS). We focus on STEM students, those receiving higher-education degrees in a Science, Technology, Engineering, or Mathematics discipline.[1]

[1] 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'). Subsequently, this paper focuses on Science, Technology, Engineering, and Mathematics (STEM) rather than Science, Technology, Engineering,

We find that a reduction of one-third in the annual flow of foreign STEM graduates at U.S. universities, sustained over time, would reduce the number of employed high-skill STEM workers in the United States by 6.2 percent. 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 percent decline in the number of Ph.D. 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 U.S. economy by 3 to 6 percent (not percentage points), resulting in a loss of $220–439 billion *per year* after 10 years.

Foreign STEM talent in the U.S. workforce and at universities

Visas for foreign nationals to come to the United States 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 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 conduit through which high-skilled individuals first arrive in the United States. As one National Academies committee chair aptly observed in 2024, "The U.S. has a talent program. It's called graduate school" (NASEM, 2024).

International education is a major U.S. export industry, contributing almost $44 billion to the U.S. economy during the 2023–24 academic year (NAFSA, 2025). But the most important contribution of international talent is serving as an engine of U.S. innovation after entering the workforce. Consider that immigrants have won 40 percent of U.S. Nobel Prizes since 2000 (NFAP, 2023) and founded most of the top U.S. AI startups (Neufeld and Milliken, 2025). Of those founders, 70 percent originally came as international students (Huang, Arnold, and Zwetsloot, 2020). International students who remain in the United States after their education become some of our most productive citizens.

The value proposition extends beyond individual achievements. International graduate students are a major source of the talent enabling U.S. universities to maintain world-class research programs and U.S. companies to commercialize ideas. Patents filed by teams including foreign-born inventors are cited more frequently and have higher economic value than those filed by all-domestic teams (Bernstein et al., 2022; Kolev, 2025). In engineering fields, 54 percent of workers with doctoral degrees originally came to the United States on student visas (Neufeld and Kaushik, 2024).

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 population is 15 percent, but foreign-born workers make

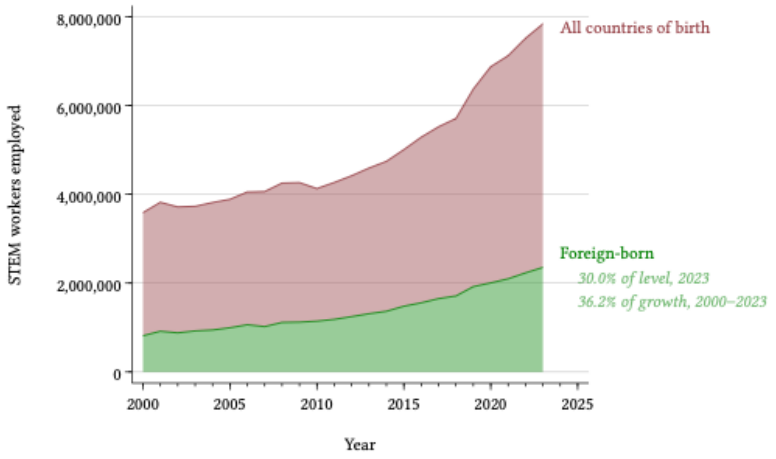
Mathematics, and Medicine (STEMM). While medicine is deeply interconnected with science and engineering, graduate medical education has different and distinct goals, structures, and systems that are not addressed in this commissioned paper.

up 30 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).[2] The figure shows a snapshot of the population in each year—that is, a stock rather than a flow.

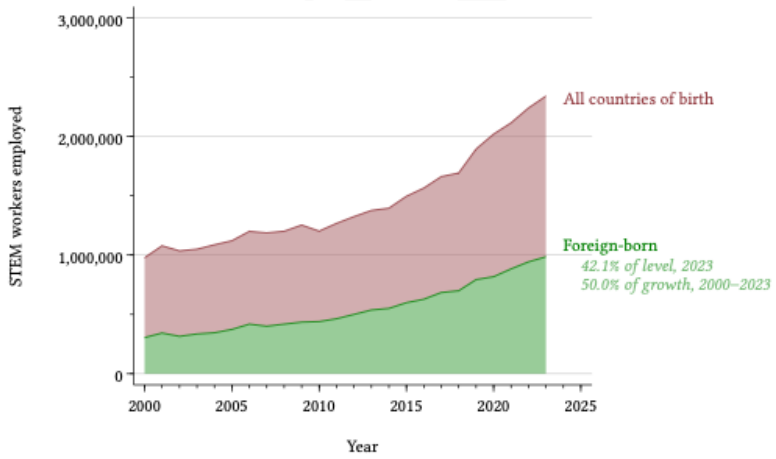
The role of immigrants is even more central at higher levels of skill. Foreign-born workers make up 42.1 percent of today's employed STEM workers whose highest degree is a master's. And the foreign-born constitute 50 percent of all growth in employed STEM workers whose highest degree is a master's since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

[2] Data from the American Community Survey 1-year public-use files.

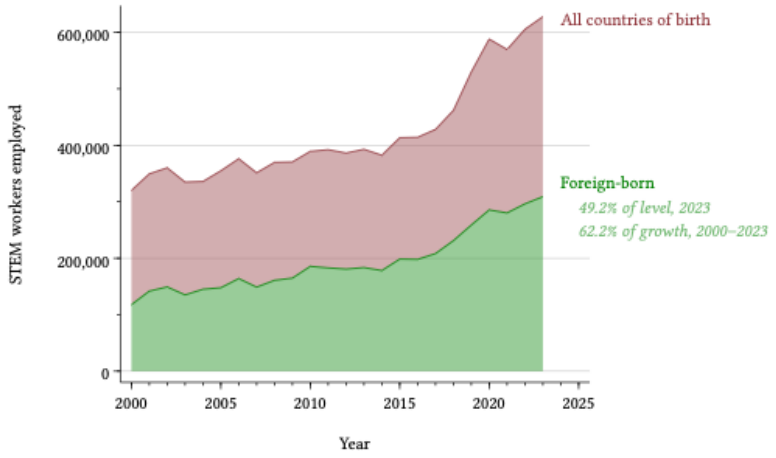
(a) All high-skill STEM



(b) Highest degree master's



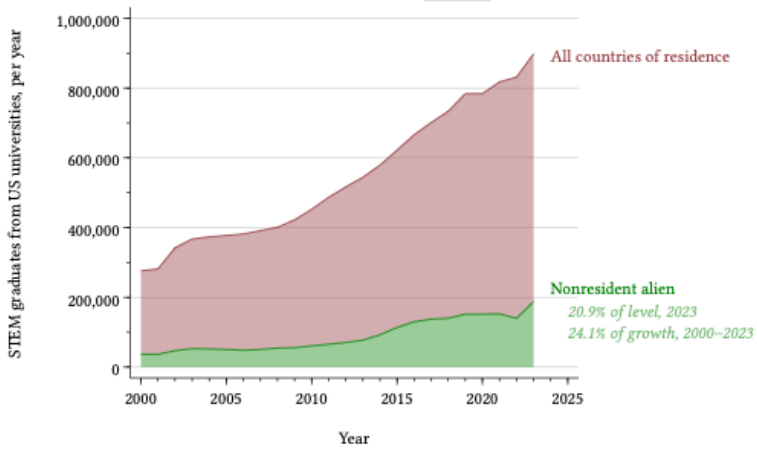
(c) Highest degree PhD



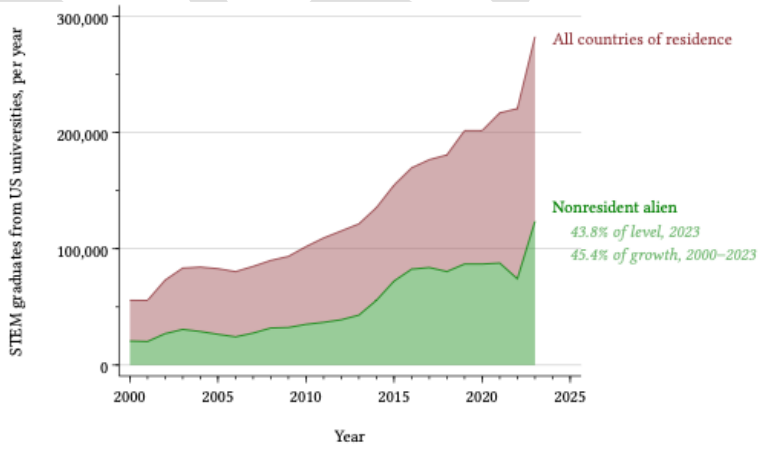
(DRAFT) **Figure 1**: Immigrant prevalence among employed U.S. high-skill STEM workers (stock), 2000–2023.
SOURCE: Author-generated.

The high 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 flow of new graduates from U.S. universities in STEM fields.[3] 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, including people on student or training visas. Nonresident aliens make up 24.1 percent of growth in the flow of STEM graduates, at all degree levels, since the year 2000 (Figure 2a).

(a) All university degree completions

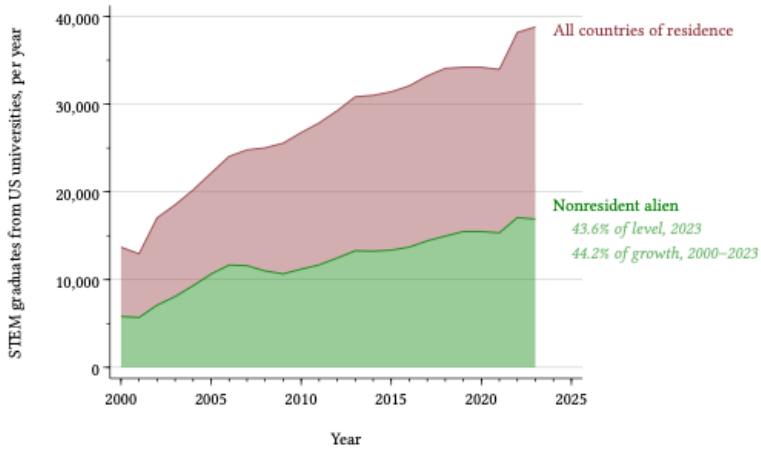


(b) Master's degree completions



[3] Data are from the Integrated Postsecondary Education Data System (IPEDS) from the National Center for Education Statistics (NCES) at the U.S. Department of Education, including processing by the Urban Institute.

(c) PhD degree completions



(DRAFT) **Figure 2**: Immigrant fraction of new STEM graduates from US universities (flow), 2000–2023.
SOURCE: Author-generated.

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. And 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. 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 percent of the current flow of Ph.D. STEM graduates are international students, and roughly the same percentage of *growth* in Ph.D. STEM graduates over the past quarter century have been international students. 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 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 U.S. high-skill STEM workforce (Figure 1)? The effect is not straightforward. Many international graduates from U.S. universities do not enter the U.S. labor force in the short-term or remain in the country in the long-term. These individuals 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.

International student transition from university to workforce

Understanding the high-skill immigration system of the United States 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).

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 U.S. borders (NASEM, 2024). 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—freedom to change employers, launch businesses, and enjoy greater career flexibility—it represents the culmination of an immigration journey rather than its beginning. The green card is the mechanism that transforms temporary workers into permanent residents, preventing brain drain rather than initiating brain gain.

While green cards primarily serve to retain talent, recruitment primarily happens elsewhere—specifically through the complex ecosystem of nonimmigrant visa programs. These temporary statuses form the 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 300,000 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 visa. 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, research institutions, and non-profits 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 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 'visitor' visa.
- **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 cards)** afford the right to stay in the United States permanently, enjoying free movement, changes of job, and retirement without sacrificing status. Only approximately 140,000 employment-based green cards are issued each year. Because spouses and minor children of the so-called "principal" beneficiaries count towards the cap, most of the 140,000 green cards do not go to the selected high-skilled principals, although it must be noted that 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). Of those 120,000 green cards, less than half go to principals, with the rest going to their spouses and minor children.

The pipeline's 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. Quotas at cap-subject institutions (like for-profit companies) mean 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 for permanent residency. 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 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 after F-1 OPT. The F-1 OPT to EB[4] 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. We define the long-term retention rate for a program as the share of a cohort in one program that ever receives 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 United States from abroad and the people transitioning from another status. Table 1 shows estimates for new arrivals; we estimate transition rates in the next section. More details on the methods can be found in the appendix.[5]

(DRAFT) **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

SOURCE: Author-generated.

- **F-1.** We estimate F-1 new arrivals using microdata from SEVIS, the Student and Exchange Visitor Information System of the U.S. Department of Homeland Security (DHS). We estimate 226,000 new F-1 students graduate each year.[6] Of those, 104,000 graduate in STEM fields and 23,000 graduate with a Ph.D.
- **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 United States each year.[7] 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 percent, suggesting an inflow of 31,000 high-skilled J-1 workers in STEM fields.

[4] In U.S. immigration, "EB" refers to Employment-Based (EB) preference categories for permanent residency.
[5] An appendix containing methods is forthcoming.
[6] 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.
[7] Clemens, Neufeld, and Nice 2024. https://www.iza.org/publications/pp/214/expelling-excellence-exchange-visitor-restrictions-on-high-skill-migrants-in-the-united-states.

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.

- **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 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 are Ph.D.'s.
- **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 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.

B. Transitions

The first major transition we consider is F-1 to F-1 OPT. OPT represents the first opportunity for post-graduation work authorization and represents a major pipeline for graduates into the U.S. workforce. SEVIS data reports directly that over the last five years of data, 54 percent of F-1 graduates attained OPT. This number is higher among STEM graduates (65 percent) and among Ph.D.'s (67 percent).

The next major transition is F-1 to H-1B. Some F-1 graduates receive an H-1B immediately, without OPT. SEVIS data suggests as much as 9 percent of a graduating class manages to change status to an H-1B without OPT. That number is higher still for STEM graduates (15 percent) and Ph.D.'s (11 percent). However, it is much more common to transition from OPT to an H-1B. SEVIS data show 29 percent of OPT participants receive an H-1B (16 percent of all graduates). Among Ph.D.'s, the share is 38 percent (25 percent of all graduates). Given STEM OPT's longer duration, it is not surprising that a greater share of STEM graduates (40 percent of OPT participants and 26 percent of all graduates) manage to change status to an H-1B after OPT. Given that some F-1s secure an H-1B through consular processing and without changing status, the true transition rates are likely about 9 percent higher than the change of status rates.

Next, we consider J-1 transition rates. 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, U.S. Citizenship and Immigration Services (USCIS) reports the average rate of transition from J-1 to H-1B was 6 percent. The transition rate from J-1 to EB-2 (non-NIW, or

National Interest Waiver[8]) and EB-3 in U.S. Department of Labor Permanent Labor Certification (PERM)[9] data is only 0.5 percent. We take the transition rate from J-1 to EB to be 1 percent.

Next, we consider the transition rate from H-1B to EB. 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. The transition rate from H1B to EB-2 (non-NIW[10]) and EB-3 for FY 2024 PERM data (which we can apply to all EB-1/2/3 principals) implies at least 50,000 H-1B holders receive approved EBs each year, though they may have to wait a long interval before their priority date becomes current. This yields a transition rate from H-1B to EB of about 50 percent, which we assume varies with the subpopulations. For simplicity, we assign 50 percent for this transition rate in aggregate and 75 percent for both STEM and Ph.D.

Finally, we consider that some F-1 graduates find other pathways we have not mapped out. Some manage to get an employment-based green card immediately without another status. Data from the Department of Labor shows that 9 percent of PERMs filed on behalf of EB-2 (non-NIWs) and EB-3s in FY2024 were filed on behalf of F-1s (and STEM and Ph.D. grads are disproportionately likely to get EB-1s and EB-2 NIWs so this is an underestimate). Further, we know that there are marriages and family sponsorship we have not counted. Not to mention, we would also like to count someone as a transition who only briefly falls out of status and spends a short amount of time abroad rather than a pure new arrival. Here, we derive transition rates using the residual method, targeting the long-term stay rates known in the literature. This means that we cannot distinguish between true F-1 to EB transitions, F-1 retention by miscellaneous other pathways, or even people that fall out of status and soon return.[11] It also means that if we undercounted another transition (for example, if we underestimated the F-1 (OPT or without OPT) to H-1B transition rates by not adjusting for enough consular processing, then these individuals may be classified under "Misc. F-1 to EB." A summary of these transition rates is provided in Table 2.

[8] Since 1990, the Immigration and Nationality Act (INA) has provided that a person of exceptional ability may obtain a waiver of the job offer requirement if USCIS deems such waiver to be in the "national interest." For more information, see https://www.uscis.gov/policy-manual/volume-6-part-f-chapter-5.

[9] A permanent labor certification (or PERM) issued by the Department of Labor (DOL) allows an employer to hire a foreign worker to work permanently in the United States. For more information, see https://flag.dol.gov/programs/perm.

[10] A "non-NIW" visa, in the context of U.S. immigration, typically refers to an employment-based (EB-2) visa that requires a job offer and labor certification, as opposed to a National Interest Waiver (NIW) which waives these requirements.

[11] 36 percent across all degree levels from USCIS data (https://www.ida.org/-/media/feature/publications/c/ch/characterizing-the-loss-of-talent-from-the-us-stem-ecosystem/product-3001891.ashx) and 65 percent for Ph.D.s across all fields (https://ncses.nsf.gov/pubs/nsb20243/table/1). For STEM, we assume an F-1 transition rate at the midpoint of the implied total transition rate of 10 percent and the Ph.D. rate of 24 percent.

(DRAFT) **Table 2**: Transitions in America's high-skilled pipeline.

	Total	STEM	Ph.D.
F-1 to OPT	54 percent	65 percent	67 percent
F-1 to H-1B (without OPT)	9 percent	16 percent	12 percent
F-1 OPT to H-1B	32 percent	41 percent	43 percent
J-1 (high-skilled) to H-1B	6 percent	6 percent	6 percent
J-1 (high-skilled) to EB	1 percent	1 percent	1 percent
H-1B to EB	50 percent	75 percent	75 percent
Misc. F-1 to EB	23 percent	29 percent	34 percent

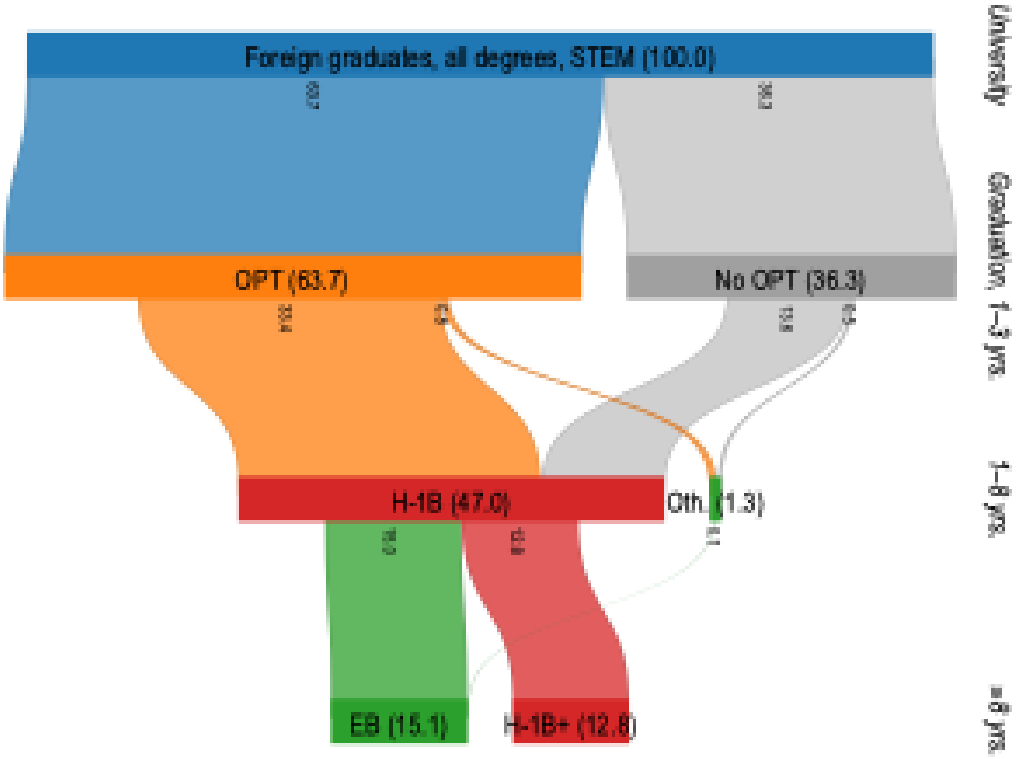
SOURCE: Author-generated.

Pathways to retention

The resulting pipeline to long-term retention is represented 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. university. The second (orange) level shows how many of those F-1 graduates 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.[12] Finally, the lowest (green and red) level represents long-term retention in the U.S. 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.[13] 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.

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

[13] 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.



(DRAFT) **Figure 3**: 'Front door' pipeline, foreign STEM graduates, all degrees.
SOURCE: Author-generated.

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. 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. The transitions to the bottom level (long-term retention) are estimated in two ways. For employment-based immigrant visas, we estimate the number of adjustments of status from nonimmigrant work visas to immigrant employment-based visas by nonimmigrant visa type.[14] For long-term retention on H-1B visas, we estimate the number of long-term extenders by comparing H-1B petition

[14] We first count the total adjustments of status to EB visas 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 U.S. universities (Mukhopadhyay and Oxborrow, 2012). 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 not subject to the 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.

approvals for continuing employment to the number of approved petitions for initial employment three years prior.[15]

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 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 U.S.; or an EB visa as a new arrival, not adjustment of status). The 'front door' includes only students who change/adjust visa status directly, without extended absence from the United States.

Figure 3 implies that 77.8 percent of international student STEM graduates from U.S. universities, at all degree levels, 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 to another nonimmigrant work visa without OPT.

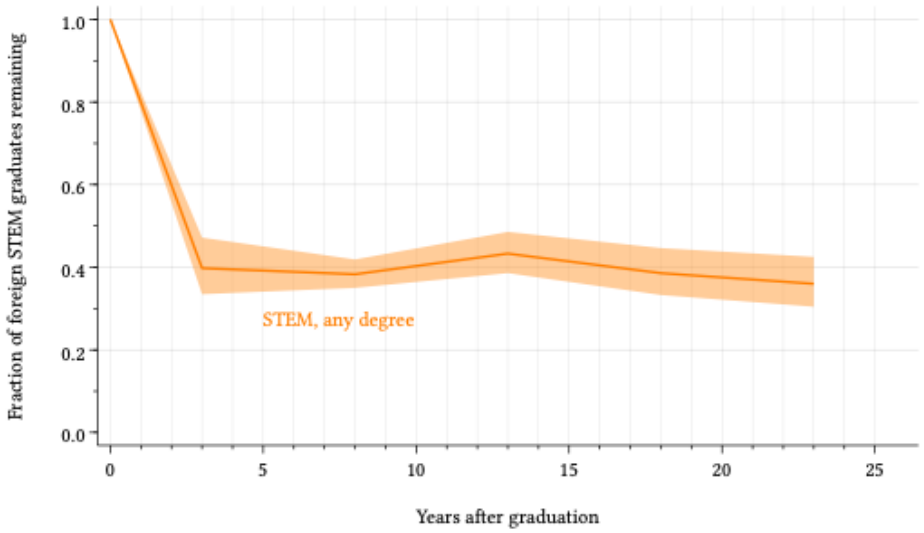
The transition to long-term retention via this 'front door' is much smaller. A major bottleneck is the availability of employment-based immigrant visas after the six-year maximum stay on a standard H-1B visa runs out (Jacobs, 2025). About 28 percent of graduates remain in the U.S. high-skill STEM workforce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

How many foreign graduates 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 U.S. 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 U.S. students (citizens and residents).[16]

This method, which should capture retention via the 'front door' and all other 'doors', implies that eight years after graduation, about 38 percent of nonresident foreign-born 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 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.

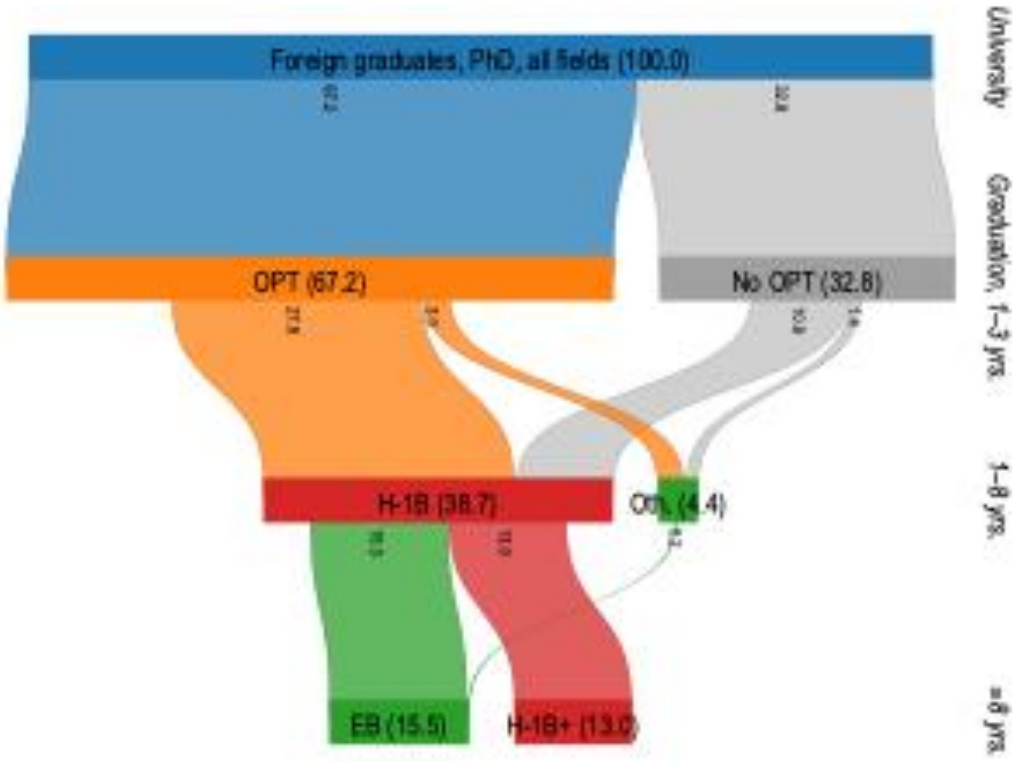
[15] The number of H-1B petitions for initial employment is primarily governed by statutory caps, so is relatively stable from year to year. Since the very large majority of H-1B visas for initial employment are extended from the original three years for an additional three years, the number of approved continuing-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.

[16] Data from the National Survey of College Graduates and NCES IPEDS.



(DRAFT) **Figure 4**: Rate of U.S. retention, foreign STEM graduates, all degrees.
SOURCE: Author-generated.

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 Ph.D. graduates of 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.

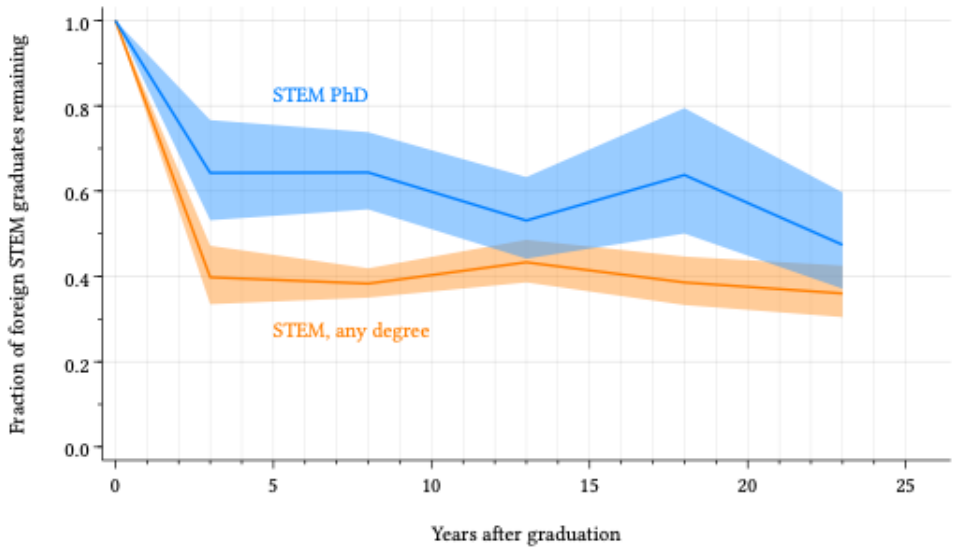


(DRAFT) **Figure 5**: 'Front door' pipeline, foreign Ph.D. graduates only, STEM and non-STEM. SOURCE: Author-generated.

How many Ph.D. graduates use other pathways to remain in the United States? Figure 6 repeats the overall retention analysis of Figure 4, for STEM Ph.D. graduates specifically (and includes 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 to 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 appears to be temporary departure from the United States, employment by a multinational, and return on an L-1 intracompany transfer visa, followed by adjustment to an EB-1 immigrant visa; another 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.

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 estimate by National Science Board from 2021 (NSB 2024).[17]

[17] Others have estimated lower attrition rates for STEM 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), though these estimates based on the Survey of Doctorate Recipients rest on reported departures among survey respondents—a



(DRAFT) **Figure 6**: Rate of U.S. retention, foreign STEM graduates, Ph.D. only vs. all degrees. SOURCE: Author-generated.

Effects of a reduction in international students on the STEM workforce

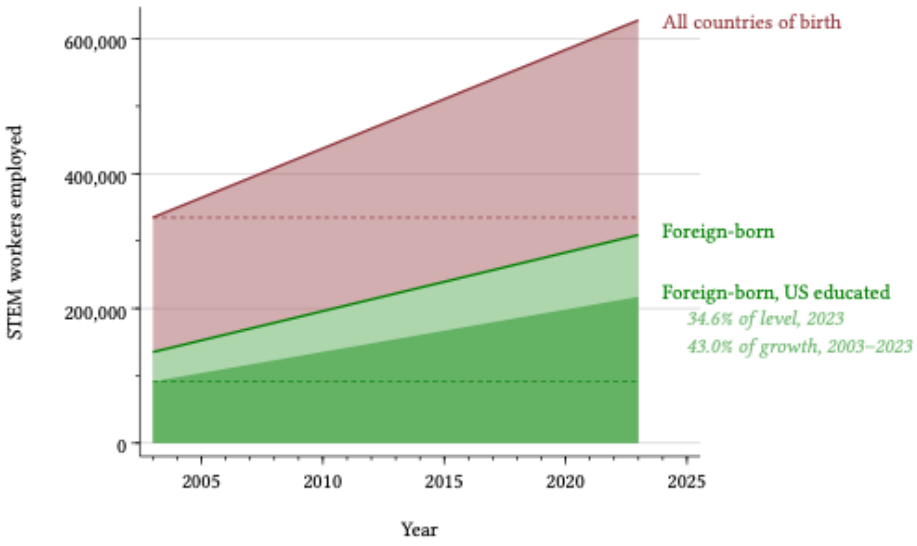
We use the above retention data to model mechanistically the short- and long-term impacts on the U.S. STEM workforce of two different policy changes: A decline of one-third in international student enrollment, and the elimination of OPT.

Policy experiment: Reduce foreign STEM graduates from U.S. universities by one third

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 percent of the high-skill STEM workforce with a Ph.D. degree is made up by workers who are foreign-born *and* received their STEM Ph.D. degree in the United States (Figure 7).[18] If the number of foreign STEM Ph.D. 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, U.S.-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 percent of the current stock of high-skill STEM workers with a Ph.D.

method that may underestimate departure due to higher nonresponse by those who have left the United States.

[18] 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.



(DRAFT) **Figure 7**: Immigrant prevalence U.S. Ph.D. STEM workers; snapshot of the population in each year (stock), 2000–2023.
SOURCE: Author-generated.

We show the results of applying the same method to various degree categories in Table 3. 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 percent today, for Ph.D. graduates specifically. It implies a 14.3 percent reduction in the *increase* of Ph.D. STEM workers over the past two decades. Across all degrees collectively (bachelor's or higher), it implies a mechanical reduction of 6.2 percent in the number of employed STEM graduate workers today, and a 7.6 percent 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 percent in the overall number of employed STEM workers with a master's as their highest degree.

(DRAFT) **Table 3**: Long term impact scenario, one-third 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%

SOURCE: Author-generated.

An alternative way to conceptualize the workforce impact of a one-third reduction in international student graduates is the immediate, short-term impact on U.S. 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 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 nonimmigrant visa categories. 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 $1/3 \times 0.209 \times 0.778 = 5.4$ percent.

Table 4 shows this impact for various degree levels. The same mechanical impact for STEM master's graduates implies a short-run reduction of 11.0 percent in the number of newly-graduated workers. For STEM Ph.D. graduates, this short-term reduction is 11.5 percent.

(DRAFT) **Table 4**: Short term impact scenario, one-third reduction in foreign STEM graduates.

	Foreign graduates, 2023	Total U.S. & for. graduates, 2023	U.S. 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 Ph.D.	16,905	38,794	0.794	–11.5%

SOURCE: Author-generated.

Policy experiment: Eliminate Optional Practical Training

OPT is the critical "bridge span" between student status and the first rung of employment-based visas. It buys employers up to three years (for STEM graduates) to test, mentor, and petition promising international graduates for H-1Bs or other statuses. Eliminating OPT removes the only legal work authorization available to most F-1 graduates immediately after finishing their degree 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, almost every student who would have used OPT as a holding pattern while waiting on the lottery now faces a forced exit point instead of a gateway.

Figure 3 shows that 63.7 percent of new foreign STEM graduates over the last five years pass through OPT, with most of those changing to another nonimmigrant employment visa (34.2 percent of the original graduates, or 53.7 percent of those who received 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 U.S. workforce, the pipeline that the majority of those graduates (3 out of 4) rely on 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 percent 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 percent.[19] Comparing this to the 48.3 percent of STEM graduates across all degree levels who reach the third level of Figure 3 currently, this scenario implies a reduction of 35 percent in the number of foreign STEM graduates retained in the U.S. workforce in the long term. This in turn, revisiting the method used in Table 3, implies a long-term reduction of 6 to 7 percent in the overall number of high-skill STEM workers in the U.S. 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 percent of STEM graduates at all degree levels enter the U.S. 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 percent.[20] That is, the number of new foreign STEM graduates entering the workforce immediately after graduation would fall by 59.9 percent. Because foreign graduates are 20.9 percent of all new STEM graduates (Figure 2), this would imply a mechanical reduction of 12.5 percent in the *total* number of new STEM graduates (foreign, resident, or domestic) entering the U.S. 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 impact 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). This 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 for education.

[19] 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 $14.1 + (63.7 \times (0.5 \times (34.2/63.7))) = 31.2$.
[20] $(34.2 \times 0.5) + 14.1$.

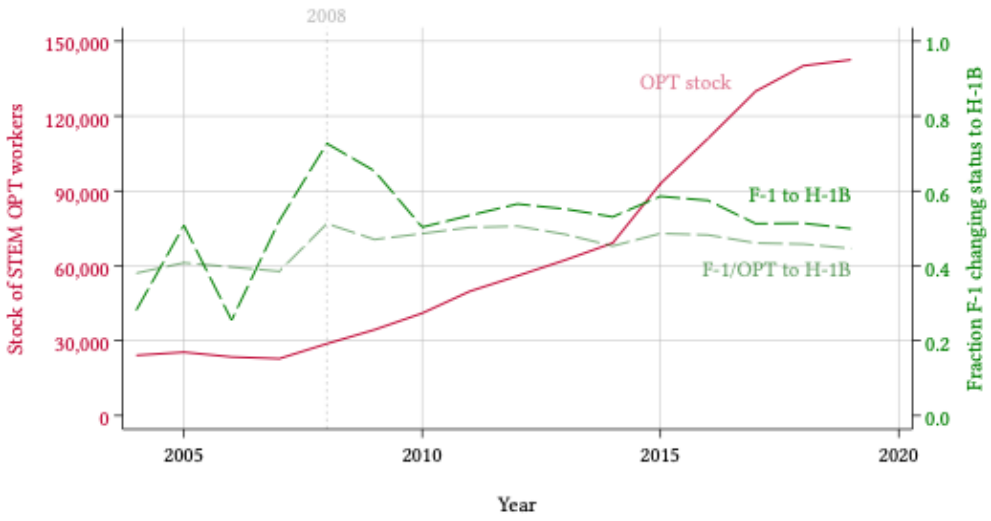
Responses by other STEM workers

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 U.S. universities, of immigration by foreign-educated foreign workers. A second involves the possible reaction by 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 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 EB immigrant employment visas for the majority of foreign workers, whether educated in the United States or not. Thus, it is possible in principle that reductions in the number of U.S.-trained foreign STEM workers receiving these visas could cause an offsetting increase in 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. 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 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.



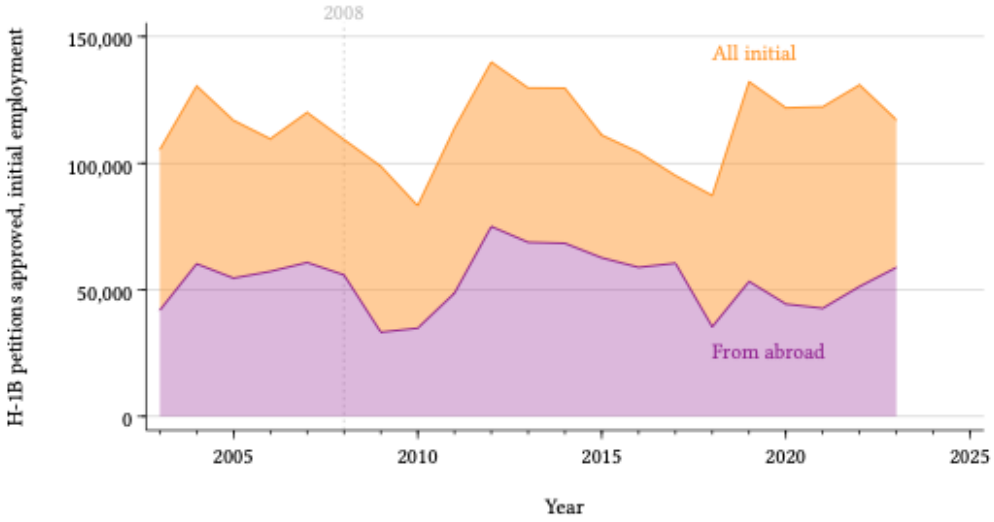
(DRAFT) **Figure 8**: STEM graduates on OPT and transitions to H-1B, pre-COVID.
SOURCE: Author-generated.

This did not occur. 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 U.S.-educated foreign STEM workers.

Nor did the very large expansion of U.S.-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 amid tightened H-1B restrictions by the first Trump administration in 2018.

There is little sign that foreign-educated foreign workers were crowded out, however. 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 U.S.-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.



(DRAFT) **Figure 9**: New-arrival H-1B workers from abroad, pre-COVID years.
SOURCE: Author-generated.

Together, Figures 8 and 9 are inconsistent with the idea that the large expansion of 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 of U.S. universities 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, however, is not definitive and should be the subject of further inquiry.

Substitution by U.S.-born citizens 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 U.S.-educated foreign STEM workers could cause an offsetting increase in the supply of STEM graduates among U.S.-born citizens and residents. This can be tested empirically: If declines in the supply of international students tend to 'crowd in' U.S. students, we should observe rises in the supply of international students to 'crowd out' U.S. students.

A large research literature has investigated this possibility. It has found no evidence that international students systematically crowd out U.S. students at the national level (Borjas, 2007; Jackson, 2015; Shen, 2016). Ransom and Winters (2021) find the same for STEM students in the 1990s, on average across all U.S.-born students, 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 domestic student enrollment, in part because revenue from foreign student tuition allows universities to expand programs available to domestic students (Shih, 2017; Bound et al., 2020). Increases in the foreign STEM workforce of U.S. cities leads to greater specialization of domestic 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 U.S.-trained, causes U.S. workers to adjust the task content of occupations in ways that create greater complementarity with foreign workers—offsetting competition that might have dissuaded domestic students from studying STEM fields. This is likely why there was an increase in the wages of exposed domestic STEM workers overall associated with the 2008 expansion of OPT (Demirci, 2020)—that is, it increased the incentive of U.S. students to study STEM fields.

A limited set of studies have found crowd-out of domestic STEM students by foreign-born 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 an Ivy League institution: a rise in the prevalence of students in any group tautologically requires a decline in the number of students in any other group if the total number of students is fixed. 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 illustrates this vividly. 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 domestic 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 domestic students for a fixed number of classroom slots before they graduate, or competing with foreign-educated workers for a fixed number of work permits after they graduate—to the first order. Beyond this, the section to follow will discuss evidence in the literature of a range of effects of foreign students on U.S. productivity, innovation, entrepreneurship, and economic growth. If foreign STEM students were anywhere near perfect substitutes for domestic 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 domestic students, leaving economic outcomes unchanged. As we discuss below, the evidence on the broader economic impacts of foreign STEM students and workers is inconsistent with this conjecture. Increases in the supply of foreign STEM students, at the national level, act as complements for domestic 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 graduates at U.S. universities would substantially crowd in domestic STEM enrollment—are nevertheless informative about real-world impacts.

Effects on U.S. growth and productivity

The research literature contains 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 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).

A very large and essentially uncontested body of research finds that these positive economic effects 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 U.S. domestic workers. (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 domestic workers (Hunt, 2011); foreign STEM Ph.D. students report greater preference for entrepreneurship than their U.S. domestic 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).

A common idea is that highly educated immigrants increase innovation with their own new ideas. Beyond this, however, high-skill immigrants cause innovation *by U.S.-born citizens*. Beine et al. (2024) find that roughly one-third of the positive effect of foreign master's graduates on U.S. entrepreneurship arises from business creates by U.S.-born citizens. Bernstein et al. (2022) find that immigrant inventors cause their domestic 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 U.S. cities (Kerr and Lincoln, 2010; Winters, 2014), increased entrepreneurship in U.S. regions (Tareque et al., 2024), and at U.S. firms, increased employment of high-skill domestic 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). Taken together, 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 U.S.-born citizens for socially-intensive tasks at work (Hanson and Slaughter, 2017). This specialization is an emergent feature of groups that include both immigrants and U.S.-born citizens, 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 domestic 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 U.S. 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 to 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 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 US labor force, the 6.2 percent 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 to 0.158 percentage points in annual TFP growth, arising from ongoing reduction of one-third in the number of high skill foreign graduates from U.S. universities.

While a seemingly small number, this is a very large impact. With U.S. GDP currently at $27.7 trillion per year, that reduction in total value added by the U.S. economy implies an ongoing annual loss that rises by $22.0 to $43.9 billion each year. That is, the loss to the U.S. economy is $22.0 to $43.9 billion in the first year of such reduced TFP growth, $44.0 to $87.8 billion in the second year, and so on. The U.S. Bureau of Labor Statistics estimates that TFP accounts for roughly one-third of the average 2.6 percent annual growth in real GDP per capita in the private business sector over the last 30 years.[21] This implies that the effect of cutting foreign STEM students from universities by one-third would have the ongoing effect of reducing annual real GDP growth by 3 to 6 percent. This is not a percentage-point impact. It implies that the annual dollar value increase in the real value added of the U.S. economy would be 3 to 6 percent lower than the increase that would have occurred without the exclusion of foreign STEM graduates.

Conclusion

The United States' current immigration system is not designed well to retain international talent in the U.S. STEM workforce. When over 70 percent of international students say they would stay if visas were readily available, but actual retention rates lag far behind, the problem lies in policy design.

[21] BLS Productivity Tables at https://www.bls.gov/productivity/tables.

The most immediate needs are expanding Optional Practical Training (OPT) and creating smoother transitions to permanent status. OPT has proven successful—over 242,000 international students were using OPT in 2023-24—but remains limited in scope and bottlenecked by H-1B and EB caps that have not kept pace.

The challenges facing the United States' high-skill immigration system extend 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 Denver-Boulder, Pittsburgh, and Raleigh-Durham. 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. This retention creates regional clusters of expertise that support both established companies and startup formation. However, 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. holders, including through migration to other regions. The Northeast does even worse at retention. The Midwest and South significantly outperform the Northeast and Mid-Atlantic, while the West Coast does best of all.

Informed policy-making 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 and are based on information that currently 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 and existing surveys like the NCSES surveys that provide rich information on STEM graduates and 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.

Current system dysfunction creates a dangerous feedback loop. As wait times grow and uncertainty increases, fewer top candidates will choose the United States as their preferred destination.

Meanwhile, other countries modernize their systems and actively recruit the talent the United States is losing.

U.S. 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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