International STEM Graduate Students: A Key to Strengthening the American Economy and Building Competitiveness

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Executive Summary: The United States (US) is renowned for offering world-class education to thousands of international students seeking advanced degrees in the STEM fields. However, the US is at risk of losing a significant portion of this talent due to limited visa options. While US funds and resources are invested in training international STEM graduate students, many students are compelled to leave the US for other countries with more favorable visa policies. This potential loss of talent is particularly concerning as China is poised to overtake the US in Research and Development (R&D) investment, while countries like Canada, the United Kingdom, and Australia, along with China, are seeking to attract foreign high-skilled STEM talents with their visa programs. STEM jobs comprise 48% of the 100 fastest growing jobs in the US while STEM industries such as the semiconductor sector already struggle to meet their growing demand for high-skilled workers. These demands can be alleviated by international STEM graduate students. In order for Congress to leverage this economic opportunity before losing American-trained students to other countries, we propose the following: i) Exempt international STEM graduate students from the visa requirement of proving their intent to leave the US after graduation, ii) Increase or circumvent the annual numerical employment green card cap for international STEM graduate students, iii) Extend the unemployment grace period for H-1B and OPT visa holders to allow sufficient time to find a new job.

I. Investing in STEM training

International STEM graduate students in the United States (US) constitute a unique class of non-citizen individuals who are often funded by US dollars and are expected to stay in the US for the duration of their studies with no promise of a subsequent job or permanent residency. In 2021, around 60,000 international master's students and 14,000 international doctoral students graduated from STEM programs in the United States (Olszewski et al. 2024). For doctoral students, the median time to degree is between 6 and 9 years depending on the field (Falkenheim 2023), and the cost (tuition and supplies) of a Ph.D. averages around $40,900 per year (Nam 2023), though for many STEM students, that cost is offset by US funds. In 2022, 85.1% of STEM doctoral students and 28.4% of STEM master's students received either institutional or federal

funding (Smith 2024, table 3-1). While the exact investment in international STEM graduate students is not precisely known, these figures suggest that for foreign doctoral students alone, the US spends at least one to two billion dollars annually. These investments are largely worthwhile when students stay in the US. A University of Pennsylvania Wharton School financial model estimates that simply exempting "immigrants with advanced STEM degrees from numerical limitations on green cards would reduce deficits by $129 billion over the 2025-2034 period" (Arnon et al. 2024). Beyond the direct financial gains, advanced international STEM graduates bring with them unique expertise, novel business ventures, and increased economic growth and international competitiveness for US markets.

However, not all international graduates remain in the US. International Ph.D. students, who have the highest rate of staying among all levels of higher education, still leave the US 23% of the time after graduation (Corrigan, Dunham, and Zwetsloot 2022), representing a loss of hundreds of millions of US dollars per year. Ultimately, entering the US workforce and maintaining immigration status is difficult for international students once they are no longer on a student visa. Here, we summarize these challenges, explain why graduate student exodus is a detriment to the American economy, and outline how this problem can be fixed through policy to retain more international STEM graduate students who are trained in the United States.

II. Limited visa options

An American Physical Society survey of international students demonstrated that 70% of the respondents faced visa challenges, waiting up to a year to obtain an F-1 (student) visa and having to prove non-immigrant intent (APS 2021). After graduation, international STEM students may work for up to 3 years on an Optional Practical Training (F1-OPT) visa (US CFR, Title 8, §214.2(f)(10)(ii) 2024). International graduates have limited visa options to work in the US beyond OPT. The most common paths are obtaining a temporary H-1B visa or permanent resident status, each with unique challenges (Citizenship and Immigration Services 2023).

i. H1-B visas

H-1B visas are temporary work visas for those employed in the US. There are 65,000 H-1B visas available each year, with an additional 20,000 slots for US master's and doctorate degree holders, which is far below the number of applicants. A qualified applicant's chance of being randomly selected for a visa is 26% for 2025 (Citizenship and Immigration Services, "H-1B Electronic Registration Process" 2024). Even after winning the lottery, H-1B workers face uncertainty. If laid off, they have a 60-day grace period to find a new job in the US (US CFR, Title 8, §214.1(l)(2) 2024), despite that the average median length of unemployment for the entire US workforce was 81 days between 2013 and 2023 (Bureau of Labor Statistics, "Median Weeks Unemployed" 2024). Indeed, a 2023 presidential advisory panel recommended increasing the grace period to 180 days (Department of Health and Human Services 2023). Finding a job within the 60-day grace period is even more difficult for international workers because not every position qualifies and not every employer is willing or able to hire temporary visa holders. While there might be other options, such as the J-1 Exchange Visitor visa, these are often restricted to certain employers or require visa holders to return to their home country, as they are meant to be temporary visas.

ii. Permanent residence

International graduates may be able to apply for permanent resident status through employment-based green cards. The last time Congress raised the number of employment-based green cards, it capped the number at 140,000 per year and set country-specific quotas (US Code, Title 8, §1151(d)(1); Immigration Act of 1990). Because spouses and children are also counted towards that cap, less than 45% of all employment green cards went to workers themselves in 2022 (Nowrasteh 2023). Due to the small number of green cards granted, it can take between 2 to more than 10 years for a high-skilled international worker to receive permanent resident status (Department of State 2024; Citizenship and Immigration Services, "Historical National Median Processing Time" 2024). In addition to long green card wait times, the immigration system can be prohibitively costly to early-career graduates. As of summer 2024, an unmarried international graduate self-petitioning for the advanced degree green card category has to pay at minimum $3345 in filing fees (I-140, I-485, I-131, and I-765)(Citizenship and Immigration Services, "Fee Calculator" 2024). Because the

paperwork is complex and there can be serious consequences for errors, petitioners often need to additionally pay hefty legal fees, which can range from $3000 to more than $10,000 (Bray 2024, Ellis Porter 2024), all while waiting years for the process to be completed.

iii. Security concerns

National security is an important consideration when discussing policies for international students and workers, particularly when those individuals will be working in critical technological sectors. No applicant in the US can obtain a green card unless the Department of Homeland Security receives the required background check and biometric information (Citizenship and Immigration Services 2022). For visa applicants abroad, the Department of State conducts security checks and, if needed, runs an often months-long vetting process called Administrative Processing to alleviate any security concerns (Bureau of Consular Affairs 2024). Congress also recently banned those receiving federal research funding from participating in foreign talent recruitment programs for other nations (Prabhakar 2024).

While background checks may take some time to process, the total amount of time an applicant must wait to receive a green card is mostly due to the numerical limit of green cards available each year. Applicants must wait until employment-based green cards are released and they are at the top of the waiting list, which can take more than a decade (Department of State 2024), depending on their green card classification. The gloomy prospect of permanent and temporary visa options for international students may force them to leave the US for another country, damaging US competitiveness and technological leadership.

III. American competitiveness

i. Research and development

Losing STEM graduates disadvantages the US on the international stage. For example, China is the leading competitor to the US in research and development (R&D). The most recent spending reports place China on an accelerated path to overtake the US in total money spent on R&D by 2029 (Fig. 1A) (OECD 2024). China, South Korea, and the United Kingdom (UK) have increased their share of GDP spending at rates higher than the US since the turn of the century (Fig. 1B) (OECD 2024). The US trains students who later must leave, poising these trainees to work in competitor markets. By retaining talent and thus building competitiveness, the US will remain the central hub for scientific and technical innovations happening on a global scale. In this way, the US can increase its competitiveness in the R&D space without losing international partnerships and collaborations.

ii. Foreign visa talent programs

Many countries are competing to attract international students. Among US allies, Canada launched the Global Skills Strategy (GSS) in 2017, aiming to fast-track visa processing for high-skilled STEM talents (Norton Rose Fulbright 2017). Further, Canada introduced and subsequently met its quota for the H-1B Visa Holder Work Permit, specifically aimed at attracting US H-1B visa holders with specialty occupations (Government of Canada 2024). The popularity of Canada's H-1B permit could be due in part to the fact that US H-1B workers have only a

60-day grace period to find a new job when laid off, and Canada's permit presents an alternative solution. Similarly, Australia introduced The Global Talent Visa Program (GTVP) in 2018, targeting highly skilled international talents in the fields of energy, artificial intelligence, space, and quantum. The GTVP offers a strategy similar to GSS, which fast-tracked visa processing and provides permanent residency pathways for eligible applicants (Australia DHA 2024). In Europe, Germany introduced the Blue Card program in 2012 (Germany FOMR 2023), and the UK introduced the High Potential Individual (HPI) visa in 2022 (UK Government 2024); both programs facilitate long-term residency for highly skilled non-EU citizens in the STEM field. In fact, the UK's HPI visa targets graduates from the top 50 universities in the world, and about 40% of those universities are in the US.

Furthermore, China has recently created programs that keep and attract non-Chinese citizens' STEM talent. The Thousand Talents Program, or TTP, was launched in 2008. It is a national recruitment program that offers incentives such as research funding, housing subsidies, and other support mechanisms to encourage top-tier professionals to stay and contribute to China's innovation and

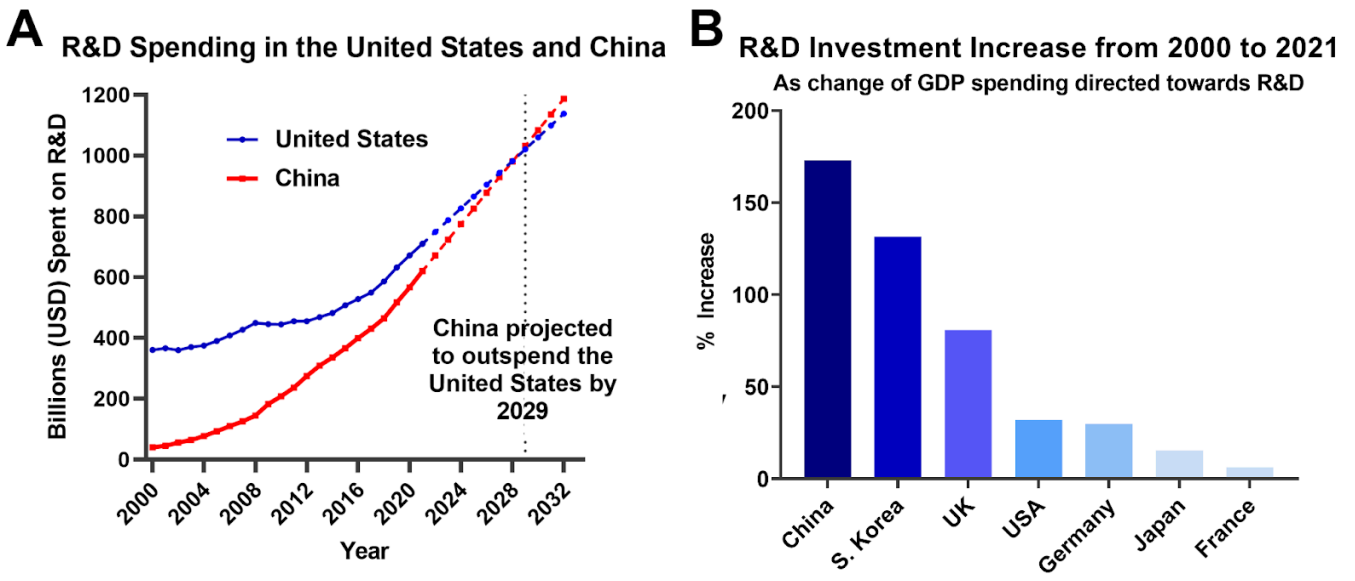

Figure 1: Increasing R&D competitiveness on the world stage. (**A**) Total money spent on R&D by the US and China, with projected spending growth after 2021 based on current trends. (**B**) Percent change in GDP share spent on R&D between 2000 and 2021 for seven leading research countries [data sourced from (OECD 2024)].

development goals (Shi, Liu, and Wang 2023). Additionally, the Overseas Talents Entrepreneurship and Innovation Program (OTEI) targets foreign professionals who want to start businesses in China by providing funding, incubation services, and preferential policies to facilitate the establishment and growth of the enterprises (Zhu et al. 2023). Adopting similar strategies for keeping STEM talent within the US would be a powerful incentive for international students to choose to stay in the US and contribute to the US economy.

IV. Economic advantages conferred by international talent

i. Maintaining growing STEM industries

48 of the 100 fastest growing jobs between 2022-2032 are in STEM fields, according to the US Department of Labor's predictions (Fig. 2A), with 8 of those STEM jobs being in the top 10 [employment growth projections from (Bureau of Labor Statistics, "Employment in STEM occupations" 2024), classified as STEM or non-STEM by codes provided by (O*NET Data 2018)]. An increasing number of specialized, trained workers will be needed to respond to this growth in a variety of fields (Fig. 2B). However, the US is experiencing an aging workforce due to the retirement of the Baby Boomer generation, and recent analysis suggests this has slowed the US GDP growth rate across the board (Maestas, Mullen, and Powell 2023). Population growth in the US is now "historically low" (Census Bureau 2023; Bier 2024), and the US birth rate has consistently been below replacement—the threshold at which a generation can replace itself—since 2007 (Osterman et al. 2024; Martin et al. 2017; CDC 2015). Therefore, there is a disconnect between the growth of STEM jobs and the decreasing growth rate in the workforce. The US can mitigate the effects of this gap by attracting international talent to fill jobs, and doing this in a proactive manner would maintain the expanding momentum of these growing industries.

The semiconductor industry provides a good example of the current shortcomings of American immigration policy and STEM workforce development. Semiconductors are materials critical to the construction of many computers and electronics today. Growing the US semiconductor industry and reducing reliance on imports is a major bipartisan concern of the federal government, as demonstrated by the 2022 CHIPS and Science Act (Chips and Science Act 2022). Despite these efforts, a lack of qualified applicants will prevent the industry from filling a growing labor shortage. According to the Semiconductor Industry Association (SIA), there is an expected shortage of 2,500 master's and Ph.D.-level engineers each year (SIA 2023). However,

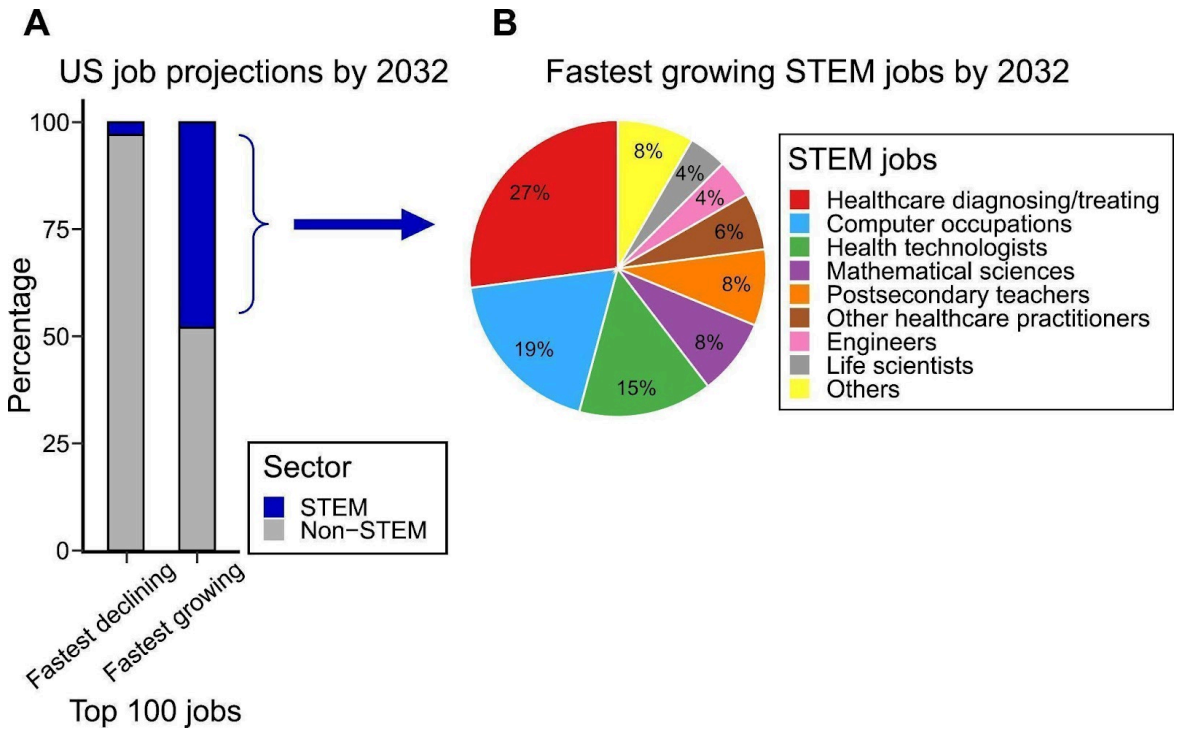

Figure 2: STEM sectors are rapidly growing. (**A**) Bar plot demonstrating the amount of STEM and non-STEM jobs in the 100 fastest declining and 100 fastest growing job markets in 2022-2032, as predicted by the US Department of Labor. (**B**) Breakdown of the fastest growing STEM jobs [employment growth projections sourced from (Bureau of Labor Statistics, "Employment in STEM occupations" 2024), classified as STEM or non-STEM by codes provided by (O*NET Data 2018)].

an estimated 16,000 foreign-born US-educated master's- and Ph.D.-level engineers in semiconductor-related fields leave annually (SIA 2023). If roughly 15% of those engineers were retained, the workforce gap would be filled.

A perennial source of concern with immigration is the impact immigrant workers have on native workers' wages. High rates of immigration can have a negative impact on the wages of US-born, low-skilled workers in some conditions (Card 2001). However, the impact of immigration of high-skilled STEM workers is far more positive. Economists at the University of California Davis and Colgate University found that increases in STEM workers in a city led to substantial wage gains for college-educated workers and, to a lesser extent, also for low-wage workers (Peri, Shih, and Sparber 2015). While the existence of a shortage of STEM workers in the US is not ubiquitous across fields and industries (Xue and Larson 2015), there does not need to be a shortage for increased STEM talent to be a benefit. Indeed, the US has a high proportion of STEM workers and yet still has a higher average STEM wage premium than comparable rich countries (Even, Yamashita, and Cummins 2023). Evidently, the demand for STEM workers is not static but can increase even as the supply increases. Introducing more STEM workers into the economy, foreign-born or otherwise, will therefore not necessarily lower STEM wages. Given the United States' especially high demand for STEM talent and the broader benefits to workers' wages, increasing the number of STEM workers is likely to be a boon to both the national and local economies. Recall that the deficit would be reduced by an estimated $129 billion over the next decade by bypassing the green card limits for those with advanced STEM degrees, largely in part due to the increased size of the workforce (Arnon et al. 2024). To minimize any potential threat to the native-born workforce, legislators can implement protections that guarantee all job postings will first be advertised to domestic workers, and that said positions must pay more than the median wage for that occupation class, as is the case for most existing work visas (Department of Labor 2009; Department of Labor 2008).

ii. Creating businesses

International students make essential contributions to the US job market and economy. The Association of International Educators reported that the over one million international students studying at US institutions contributed over $40 billion to the US economy and supported more than 368,000 jobs during the 2022-2023 academic year (NAFSA 2023). The National Foundation for American Policy showed that international students in the US were co-founders of 25% of America's startup companies valued at $1 billion or more in 2023 (Anderson 2023). These companies are estimated to be worth $143 billion and created an average of 860 jobs per international student founder. OpenAI, an artificial intelligence-oriented company with over $80 billion (Metz and Mickle 2024), stands out as one of the most preeminent businesses co-founded by international students. International talent gives America an edge in the global battle over technology and innovation.

The United States should remain the center for science and technology startups, for the sake of both the economy and national security. Consider, for example, the debate over the Chinese company ByteDance, which owns the popular social media app TikTok (Maheshwari and Holpuch 2024). Concerned over China's potential to influence the company and possible disinformation and data collection, Congress passed legislation in April 2024 banning TikTok in the US unless ByteDance sells the company (National Security Act 2024). While the merits of this ban can be debated, the cause of concern is the influence of foreign powers over technology that itself influences much of the population. By cultivating the globe's best STEM talent, the US can better situate itself so that future companies and technologies originate from the US and are not subject to similar national security concerns.

V. Policy suggestions

Policymaking should focus on the ability of international students to stay in the US after graduation and maintain stable immigration status for long-term retention, which benefits the US economy. Potential policy solutions should focus on developing STEM talent recruitment programs to compete with those in foreign countries such as China, the UK, and Canada. We propose three additional policy actions to existing visa programs that would alleviate the hurdles and uncertainty surrounding this process and help US industries.

i. Allow "dual intent" for international graduate students in STEM fields on an F-1 visa.

Currently, student visas are classified as non-immigrant (US Code, Title 8, §1101(a)(15)(F)(i)), so students must demonstrate a "non-immigrant intent" and a desire to leave the US after graduation to receive the visa. With dual intent, a student can more easily study in the US, renew their visa, and return to the US after visiting their home, all without having to prove to immigration officials that they will leave after graduation. By not being expected to express an intent to leave, students will be on a more stable path to staying in the US and contributing to the American economy and society after graduation.

ii. Exempt international graduates with advanced STEM degrees awarded by US universities from the annual employment-based green card limit to reduce wait times and provide a more certain path to residency for all graduates who wish to stay in the US.

In lieu of enacting such a measure, introduce at least 20,000 additional employment-based green cards per year reserved for these international students, as this approximates the number of international graduates who leave the US every year (Olszewski et al. 2024; Corrigan, Dunham, and Zwetsloot 2022). Congress established a similar proposal to reserve 20,000 temporary H-1B visa slots for international graduates of American universities with advanced degrees (US Code, Title 8, §1184(g)(5)(C)). To maximize advanced STEM graduate retention, the number of annual reserved green cards should be increased to meet this demand.

iii. To reflect job search and job market uncertainties, increase the unemployment grace periods for F1-OPT, F1-STEM-OPT and H-1B visas to 180 days, as recommended by a presidential advisory panel (Department of Health and Human Services 2023).

H-1B workers who become unemployed currently have 60 days to find a new job in a similar sector and with a similar employer, or else they face losing their visa status entirely (US CFR, Title 8, §214.1(l)(2) 2024). However, the average unemployment time was more than 80 days in the past decade (Bureau of Labor Statistics, "Median Weeks Unemployed"

2024). In many of these high-skill positions, new jobs may require multiple rounds of interviews and technical assessment. By increasing this grace period to more than the average unemployment period, the risk that advanced international STEM graduates take by remaining in the US on a work visa is substantially reduced, and the ability of these high-skilled workers to stay long-term is improved.

The implementation of these proposed policies would be relatively straightforward as they do not require the creation of new agencies or bureaucracy; they would be extensions of current US immigration laws and regulations, should Congress and the Department of Homeland Security approve them. Dual intent student visas (i) and increased green cards for STEM graduate students (ii) would need congressional approval, while H-1B and OPT grace period increases (iii) may be implemented more quickly through executive action (Department of Health and Human Services 2023). Proper implementation must include comprehensive training of immigration officers on these new rules, so as to avoid improper green card or visa rejections when students and graduates are relying on these rules to apply for visas. In all these cases, policymaking to address the shortcomings in retaining advanced STEM graduates of US institutions is actionable, and it will be helpful for future policymaking to define these graduates as a potential immigrant class in American law. Broader immigration issues may get conflated with this specific case, making Congressional action less likely unless this is discussed in a focused manner.

Congress has not acted despite the emerging issues and available solutions, though some of these provisions—namely, green card cap exemption and dual intent—were proposed in the bipartisan Keep STEM Talent Act of 2023 (Congress S.2384 2023; Congress H.R.5477 2023). The existence of this bill makes it the most immediate option available to Congress. Regardless of the fate of any particular bill, legislation on this issue should continue to attract bipartisan appeal and should encompass the policy suggestions described herein to maximize the positive effect on the US economy and national R&D.

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