Retaining Foreign Talent:

The Impact of the OPT Extension on Employment in STEM Occupations

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Abstract

This paper examines whether extending post-graduation work authorization helps retain foreign STEM graduates in STEM occupations in the United States. In 2016, the Optional Practical Training (OPT) reform increased the maximum work authorization period for eligible F-1 STEM graduates from 29 to 36 months, while leaving the 12-month period for non-STEM graduates unchanged. Using 2012–2023 American Community Survey data and a difference-in-differences design at the commuting-zone level, I find that the number of young foreign-born graduates working in STEM occupations increases more for those with STEM degrees than for those with non-STEM degrees after the reform. No statistically significant difference between degree groups is observed in non-STEM occupations. A triple-difference analysis further shows that this relative increase within STEM occupations is significantly larger among foreign-born graduates than among graduates who are U.S. citizens. Among U.S. citizens working in non-STEM occupations, I also find suggestive evidence that the number of STEM graduates increases relative to that of non-STEM graduates. This pattern is consistent with occupational specialization based on comparative advantage. These findings suggest that longer post-graduation work authorization can help retain foreign graduates in STEM occupations, alongside possible occupational reallocation within the same local labor markets.

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1 Introduction

International students constitute a substantial pool of potential skilled workers for the United States. In the 2022/23 academic year, more than one million international students were enrolled at U.S. higher education institutions or participating in Optional Practical Training (OPT), and 55 percent studied science, technology, engineering, and mathematics (STEM) fields (Institute of International Education, 2023). Retaining this talent has potential benefits beyond the employment of the graduates themselves: research on skilled immigration finds that immigrants boost innovation, as measured by patenting per capita across U.S. states (Hunt and Gauthier-Loiselle, 2010), and that increases in foreign STEM workers raise productivity growth and native wages in U.S. cities (Peri et al., 2015). Yet foreign students cannot remain in the U.S. labor market after graduation without work authorization, and policies that grant work authorization based on a student's degree field do not guarantee that graduates will work in STEM jobs.

Does extending post-graduation work authorization increase employment of foreign STEM graduates in STEM occupations? This paper examines this question using the 2016 OPT reform, which increased the maximum work authorization period for eligible F-1 STEM graduates from 29 to 36 months while leaving the 12-month period for non-STEM graduates unchanged. The reform provides a setting in which eligibility differs by degree field, allowing me to examine whether the employment response is concentrated in STEM occupations. A central empirical challenge is to distinguish the response associated with the reform from broader changes in demand for STEM graduates. I address this challenge by comparing employment changes across degree fields, occupations, and worker groups.

To do so, I use American Community Survey (ACS) microdata from 2012 to 2023 to construct local employment counts by degree field and occupation across the 52 commuting zones with the largest presence of foreign graduates. Because the ACS does not report visa status, I proxy for former F-1 students—whom I refer to as *likely* F-1 workers—using employed noncitizens aged 25–29 who arrived in the United States between ages 16 and 20 and hold a bachelor's degree as their highest degree. Within STEM occupations, I first use a difference-in-differences (DD) design to compare employment changes between likely F-1 workers with STEM and non-STEM degrees before and after the 2016 reform. I then estimate a triple-difference specification that compares this degree-

based gap with the corresponding change among U.S. citizens of the same age and education level, which helps separate the effect of the OPT extension from broader shifts in labor demand for STEM graduates.

After the 2016 OPT extension, employment in STEM occupations rises for likely F-1 workers with STEM degrees relative to those with non-STEM degrees. I find that for every likely F-1 worker with a non-STEM degree employed in a STEM occupation, there are about 125 percent more likely F-1 workers with STEM degrees after the reform than before it. This relative increase is positive and significant. In non-STEM occupations, I find little evidence of a comparable shift, and a direct comparison confirms that the relative increase is significantly larger in STEM occupations. Within STEM occupations, the shift toward STEM graduates is also significantly larger among likely F-1 workers than among U.S. citizens.

These results suggest that longer post-graduation work authorization helps retain foreign STEM graduates in STEM occupations. In an event-study analysis, the employment gap between STEM and non-STEM degree holders among likely F-1 workers in STEM occupations is flat in the years just before the 2016 extension (2013–2015) and then widens steadily after the reform, with statistically significant gains from 2018 through 2023. Meanwhile, among U.S. citizens working in non-STEM occupations, I find suggestive evidence that employment of STEM degree holders increases relative to that of non-STEM degree holders over the same period. Because foreign graduates have a relative advantage in technical tasks while native graduates have stronger English language and communication skills, this pattern is consistent with occupational specialization based on comparative advantage, with foreign STEM graduates concentrating in technical STEM jobs and domestic STEM graduates sorting into communication-intensive non-STEM roles.

This paper contributes to the literature on work authorization and international students' transition into host-country labor markets. Studies of the earlier 2008 OPT extension examine foreign students' educational choices (Amuedo-Dorantes et al., 2019) and their initial decisions to remain in the United States after graduation (Demirci, 2019). Related work estimates college-to-employment transition rates and international students' contribution to the skilled labor supply, including how these transitions change after the 2008 extension (Peri and Basso, 2016; Beine et al., 2023). More recently, Amuedo-Dorantes and Shih (2026) show that OPT expansions increase STEM degree com-

pletions, with gains at both the bachelor's and master's levels, and that domestic completions rise as well. Whereas these studies focus on degree completion or overall post-graduation employment, I examine the labor market effects of the 2016 OPT reform jointly by degree field and occupation. Distinguishing degree fields from occupations allows me to test whether a policy targeted at STEM majors actually expands employment in STEM jobs. By tracking young foreign graduates across local labor markets over 2012–2023, my analysis also extends work on initial post-graduation entry to capture broader retention in the local STEM workforce.

The paper also connects to research on immigration and occupational specialization. Studies of task allocation and occupational choice emphasize that foreign and domestic workers can specialize according to comparative advantage (Peri and Sparber, 2009, 2011; Mayda et al., 2026). This perspective motivates examining how employment responses differ across occupations even among workers with similar levels of education. I bring degree field, occupation, and worker group together to assess whether the relative employment increase is concentrated among likely F-1 STEM graduates in STEM occupations and how it compares with changes among U.S. citizens in the same local labor markets. These comparisons provide evidence on the distribution of employment changes across groups.

The remainder of the paper is organized as follows. Section 2 describes the institutional background. Section 3 presents the theoretical motivation for distinguishing degree fields from occupations and develops a model of occupational specialization. Section 4 presents the data and sample construction. Section 5 presents the difference-in-differences and triple-difference designs. Section 6 reports the employment results across occupations and worker groups. Section 7 uses an event study to assess whether pre-reform employment trends for STEM and non-STEM graduates are consistent with the parallel trends assumption. Section 8 concludes.

2 Background

Foreign-born workers account for a substantial and growing share of U.S. STEM employment. As shown in Table 1, their share rose from 16.4% in 2000 to 23.1% in 2019, while their number increased from approximately 1.2 million to 2.5 million. These aggregate statistics provide context for policies aimed at retaining foreign talent. They describe the foreign-born workforce as a whole,

Table 1: Foreign-Born and U.S.-Born Workers in the STEM Workforce

	Foreign-born		U.S.-born	
Year	Workers	Share (%)	Workers	Share (%)
2000	1,229,000	16.4	6,263,000	83.6
2010	1,590,000	20.6	6,140,000	79.4
2019	2,498,000	23.1	8,324,000	76.9

Notes: Source: American Immigration Council (American Immigration Council, 2022) analysis of microdata from the 2000, 2010, and 2019 American Community Surveys.

and my analysis focuses more on the narrower group of young graduates likely to have entered the United States as F-1 students examined in this paper.

For international students who enter the United States on temporary, nonimmigrant F-1 visas, Optional Practical Training (OPT) serves as a primary pathway into the U.S. labor market. The program provides temporary work authorization to eligible F-1 students, allowing graduates through post-completion OPT to work in positions directly related to their field of study while maintaining their student status. Importantly, unlike the H-1B visa—a temporary, nonimmigrant classification for foreign workers in specialty occupations—OPT does not require an employer-filed petition to obtain work authorization (U.S. Citizenship and Immigration Services, nd).

Since the modern OPT program was established in 1992, two major policy reforms have selectively expanded post-completion work authorization for eligible STEM graduates. Prior to 2008, OPT work authorization was uniformly capped at 12 months for all graduates. In 2008, however, the Department of Homeland Security (DHS) introduced a 17-month extension for eligible graduates in designated STEM fields, raising their maximum authorization period to 29 months while leaving the standard 12-month limit for non-STEM graduates unchanged (U.S. Department of Homeland Security, 2008). A second reform in 2016 replaced the 17-month STEM extension with a 24-month extension, further increasing the maximum total period of work authorization to 36 months for STEM graduates. Taking effect on May 10, 2016, the rule again left the regular 12-month period for non-STEM graduates unchanged, while introducing formal training plans alongside enhanced oversight and worker protections (U.S. Department of Homeland Security, 2016).

These extensions can support U.S. employment of foreign workers through several channels. First, a longer authorization window gives graduates more time to gain U.S. work experience and also

gives employers more time to assess and train them. Second, it provides additional opportunities to transition to a subsequent employment-based visa, such as H-1B, before OPT expires. Third, because employers do not need to sponsor a visa petition as they would for an H-1B worker, OPT lowers initial hiring barriers and makes it easier for firms to hire foreign graduates at the start of their careers (Demirci, 2019).

3 Theoretical Motivation

3.1 Degree Fields and Occupations

Although eligibility for the STEM OPT extension is determined by a graduate's field of degree, the labor market effects of the policy depend on the occupations in which graduates actually work. In practice, degree fields and occupations do not map one-to-one: graduates with STEM degrees often work in non-STEM occupations, and workers with non-STEM degrees can likewise hold STEM jobs. My empirical design therefore defines policy exposure by degree field while examining employment outcomes separately across STEM and non-STEM occupations. Importantly, working in a Census-defined STEM occupation is not synonymous with the regulatory requirement that OPT employment be directly related to a student's major—for instance, a STEM graduate may apply technical training in a business, financial, or managerial role that the Census classifies as a non-STEM occupation. Thus, by comparing employment across occupation groups, I capture how graduates sort across jobs in the labor market rather than mechanical compliance with visa rules.

There are two reasons why the employment response to the OPT extension may differ across occupations. First, because the extension is granted for practical training tied to a STEM degree, the direct increase in foreign graduate employment should naturally be concentrated in STEM occupations. Second, foreign and domestic graduates may differ in their comparative advantage across occupational tasks, so an inflow of foreign STEM graduates can also affect how domestic graduates sort across jobs (Peri and Sparber, 2009, 2011; Mayda et al., 2026). While the program's institutional rules alone can explain why retained foreign STEM graduates concentrate in STEM occupations, they cannot account for any corresponding shift in the occupational choices of U.S.-citizen

graduates. Thus, I formalize the model based on the comparative advantage channel to explain how the policy may affect both foreign and domestic workers.

3.2 Comparative Advantage and Occupational Specialization

I closely adapt the task allocation framework of Mayda et al. (2026), which builds on Peri and Sparber (2009). Consider firms that combine the services of two occupation types $j \in \{S, N\}$, where S denotes STEM occupations and N non-STEM occupations. The services of each occupation are produced by foreign (F) and domestic (D) college graduates, who are imperfect substitutes within an occupation:

$$Q_j = \left[(A_j^F L_j^F)^{\frac{\rho-1}{\rho}} + (A_j^D L_j^D)^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}, \qquad j = S, N, \tag{1}$$

where L_j^i is the number of type-i workers employed in occupation j, A_j^i is the productivity of a type-i worker in that occupation, and $\rho > 1$ is the elasticity of substitution between foreign and domestic workers. The efficiency of each occupation, measured as output per worker, is maximized at the foreign-to-domestic ratio

$$\frac{L_j^F}{L_j^D} = \left[\frac{A_j^F}{A_j^D} \right]^{\rho-1}, \qquad j = S, N,$$

which implies

$$\frac{L_S^F / L_S^D}{L_N^F / L_N^D} = \left[\frac{A_S^F / A_S^D}{A_N^F / A_N^D} \right]^{\rho-1}. \tag{2}$$

If foreign graduates have a comparative advantage in STEM occupations, $A_S^F/A_S^D > A_N^F/A_N^D$, the optimal foreign-to-domestic ratio is higher in STEM than in non-STEM occupations. Equivalently, domestic graduates have a comparative advantage in non-STEM occupations. In Mayda et al. (2026), this pattern reflects foreign workers' relative strength in technical, research-oriented tasks and domestic workers' relative strength in communication-intensive and managerial tasks. I treat STEM occupations as the empirical counterpart of the former, while recognizing that non-STEM occupations include a broader set of jobs.

Mayda et al. (2026) further show that when the supply of skilled foreign workers is constrained, firms operate below the optimal foreign-to-domestic ratio, and that an increase in this supply allows firms to raise the ratio toward its optimal level, particularly in technical tasks. Consistent with

this prediction, they find that skilled immigrant inflows raise the immigrant-to-native ratio more in technical than in managerial tasks.

The framework suggests three patterns. First, employment of foreign STEM-degree holders in STEM occupations should increase relative to that of foreign non-STEM-degree holders. Second, a corresponding increase should be smaller in non-STEM occupations. Third, among domestic workers, those with STEM degrees—whose training is applicable in both occupation groups—may shift toward non-STEM occupations relative to those with non-STEM degrees, consistent with the occupational responses of highly educated natives documented by Peri and Sparber (2011). Because domestic workers are not subject to the work authorization constraint, comparing degree-based changes between foreign graduates and U.S. citizens also helps separate the reform from an overall increase in demand for all STEM graduates in the United States. Motivated by this model, I compare employment counts over time across worker groups, degree fields, and occupations.

4 Data and Sample Construction

The empirical analysis uses annual microdata from the 2012–2023 IPUMS American Community Survey (ACS) (Ruggles et al., 2023, 2024) to construct employment size by degree field, occupation, and worker group.

4.1 Identifying Likely Former F-1 Students

Because the ACS does not directly report respondents' visa status, I define "likely F-1 workers" as employed noncitizens aged 25–29 who arrived in the United States between ages 16 and 20 and hold a bachelor's degree as their highest degree. This restriction on arrival age builds on Peri and Basso (2016), who identify likely F-1 students as noncitizens arriving at age 16 or older, and is designed to capture individuals who likely entered the U.S. for college rather than directly for employment. In my analysis, I exclude individuals with master's, professional, or doctoral degrees because the ACS reports a respondent's field of study only for their bachelor's degree and not for any advanced degrees.

Given that the ACS records neither visa status at entry nor current visa classification, this group serves as a proxy for former F-1 students and may include some individuals who originally entered under other visa categories, as well as former F-1 students who have subsequently transitioned to another noncitizen status. The employment measure therefore may include both employment during the OPT period and subsequent employment under an H-1B or other work visa, capturing the combined retention margin through which the OPT extension operates.

As a comparison group, I use employed U.S. citizens aged 25–29 whose highest degree is a bachelor's degree, including naturalized citizens. Unlike the likely F-1 sample, this group is not subject to the arrival-age restriction.

4.2 Classification of STEM Degrees and Occupations

I classify degree fields into STEM and non-STEM categories by matching ACS detailed field-of-degree codes to the DHS STEM Designated Degree Program List (U.S. Immigration and Customs Enforcement, nd). Across the sample period, the crosswalk distinguishes 81 STEM fields and 93 non-STEM fields, and additionally includes veterinary medicine (code 1107) and data science and data analytics (code 4009) as STEM fields in 2021–2023 to reflect detailed degree codes in later survey waves.

Occupations are classified into STEM and non-STEM groups using the U.S. Census Bureau STEM occupation lists (U.S. Census Bureau, nd) and Standard Occupational Classification (SOC) codes. Consistent with the Census coding revision over the sample period, I apply the 2010 classification scheme to the 2012–2017 surveys (85 STEM and 391 non-STEM occupations) and the 2018 scheme to the 2018–2023 surveys (99 STEM and 418 non-STEM occupations). Importantly, holding a STEM degree and working in a STEM occupation are distinct classifications, as graduates from either degree group can be employed in either type of occupation.

4.3 Commuting Zones and Sample Restrictions

Because the smallest geographic unit available in the public-use ACS is the public-use microdata area (PUMA), I aggregate worker counts from PUMAs to commuting zones using the 2010 crosswalk

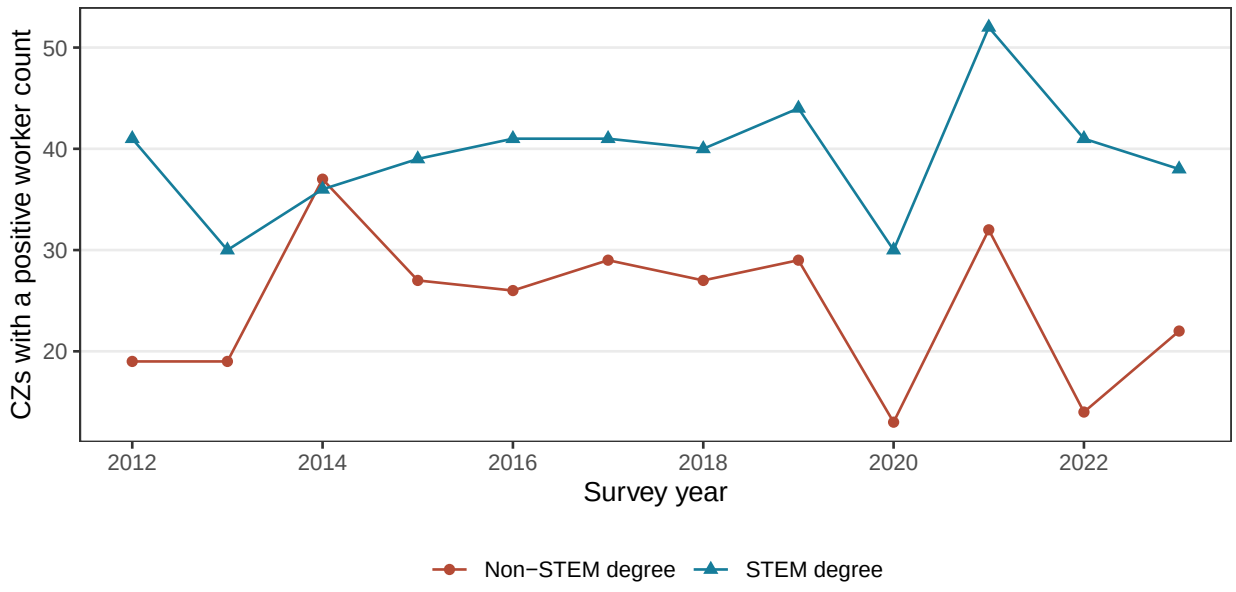


Figure 1: Geographic Concentration of Likely F-1 Workers in STEM Occupations

Notes: The figure reports the annual number of commuting zones with a positive number of likely F-1 workers in STEM occupations, separately by degree group, in 2012–2023.

from Autor et al. (2019) to measure employment at the local labor market level. Each observation is weighted by its ACS person weight multiplied by the corresponding PUMA-to-commuting-zone allocation factor. For each combination of commuting zone, survey year, worker group, degree group, and occupation group, I sum these weighted counts and assign zero to cells with no observed workers.

As Figure 1 shows, likely F-1 workers in STEM occupations are concentrated in a relatively small subset of local labor markets, and the number of commuting zones with positive employment varies across years and degree groups. Rather than estimating regressions across all commuting zones—many of which have little or no foreign-graduate identified in my data—I focus on the 52 commuting zones with the highest average number of likely F-1 workers across both degree and occupation groups over the 2012–2023 sample period. Together, these 52 major local labor markets account for 85.1% of total likely F-1 employment in the data, forming a panel of 1,248 commuting-zone–year–degree observations for each worker and occupation group over the 12-year period.

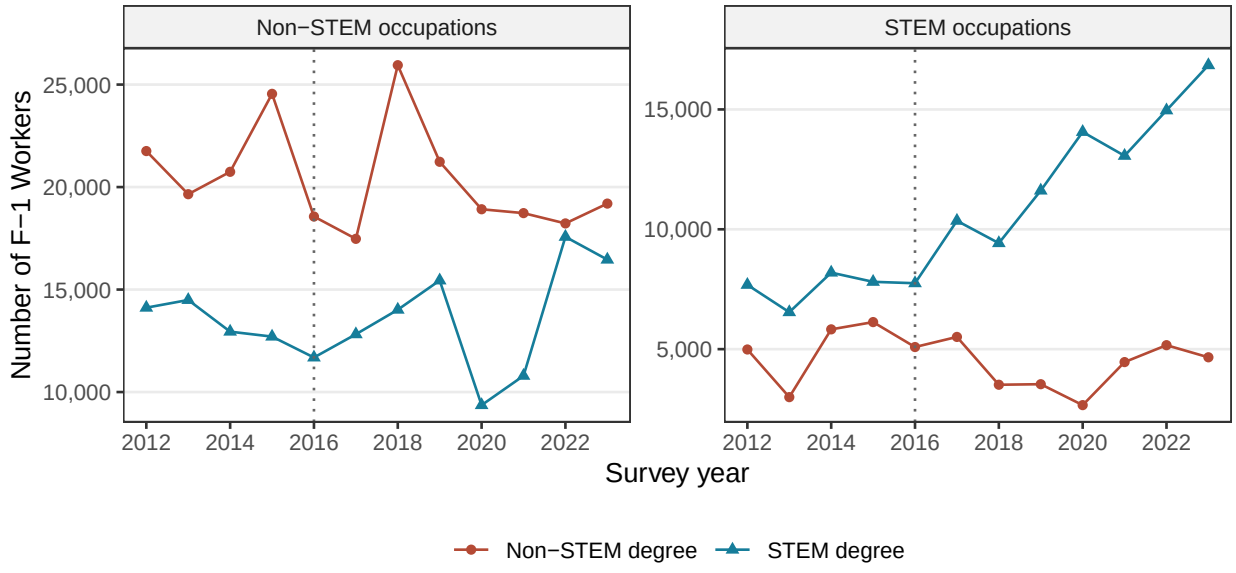


Figure 2: Likely F-1 Employment by Degree and Occupation, 2012–2023

Notes: This figure plots annual national number of likely F-1 workers by degree field (STEM vs. non-STEM) in non-STEM occupations (left panel) and STEM occupations (right panel) from 2012 to 2023. The number of workers is calculated from the full ACS sample using person weights. The vertical dotted line indicates the 2016 OPT reform.

5 Empirical Strategy

My primary empirical analysis examines whether the 2016 OPT extension increases the employment of likely F-1 STEM graduates in STEM occupations—the group and sector most directly targeted by the reform. Before turning to the regression framework, Figure 2 plots national annual employment of likely F-1 workers by degree field in non-STEM occupations (left panel) and STEM occupations (right panel). While foreign employment of STEM and non-STEM degree holders moves closely together in non-STEM occupations throughout the sample period, the gap between the two degree groups widens noticeably in STEM occupations after the 2016 reform. To evaluate this pattern across local labor markets, I turn next to a difference-in-differences analysis at the commuting-zone level.

5.1 Difference-in-Differences Design

In the baseline analysis, I compare employment changes between likely F-1 workers with STEM and non-STEM degrees among those working in STEM occupations. I estimate the same specification for likely F-1 workers in non-STEM occupations and separately for U.S. citizens in each occupation

group. Using the sample of 52 commuting zones from 2012 to 2023 (N = 1,248 commuting-zone–year–degree observations), I estimate the following specification:

$$\text{IHS}(W_{cdt}) = \alpha + \beta\,\text{STEM}_d + \theta_{DD}(\text{STEM}_d \times \text{Post}_t) + \delta_c + \delta_t + \varepsilon_{cdt}, \tag{3}$$

where W_{cdt} is the ACS-weighted number of workers in the relevant worker and occupation group in commuting zone c, degree group d, and survey year t. The variable STEM_d equals one for the STEM-degree group and zero for the non-STEM-degree group. The indicator Post_t equals one for 2017–2023 and zero for 2012–2016. Because the OPT extension took effect in May 2016, I include the transition year in the baseline period and begin the post-reform period in 2017, which is the first full calendar year under the new extension. The terms δ_c and δ_t denote commuting-zone and survey-year fixed effects, respectively.

To retain cells with zero observed workers, I apply the inverse hyperbolic sine transformation to the employment count:

$$\text{IHS}(W_{cdt}) = \log\left(W_{cdt} + \sqrt{W_{cdt}^2 + 1}\right).$$

This transformation is defined at zero and behaves similarly to a logarithm for sufficiently large counts (Aihounton and Henningsen, 2021).

The coefficient of interest in the baseline comparison is θ_{DD}, which captures the post-reform change in employment for likely F-1 workers with STEM degrees relative to those with non-STEM degrees within STEM occupations. A positive estimate of θ_{DD} indicates that employment of STEM graduates increases relative to that of non-STEM graduates following the 2016 extension. Because a causal interpretation of θ_{DD} relies on the assumption that employment of the two degree groups would have followed parallel trends in the absence of the reform on the OPT extension, I examine pre-reform trends and post-reform effects using an event-study analysis in Section 7.

5.2 Triple-Difference Design

A broader increase in demand for STEM graduates could contribute to the main pattern. To assess whether the degree-based employment change is greater among likely F-1 workers than among U.S. citizens, I estimate a triple-difference model within STEM occupations. I aggregate workers by

commuting zone, survey year, degree group (STEM degree vs. non-STEM degree), and worker group (F-1 workers vs. U.S. citizen workers). Each commuting zone and year therefore contributes four observations: STEM- and non-STEM-degree workers within each of the likely F-1 and U.S.-citizen groups. Specifically, I estimate

$$\begin{aligned}\text{IHS}(W_{cdtv}) = \alpha &+ \beta_1 F_v + \beta_2 \text{STEM}_d \\ &+ \gamma_1(F_v \times \text{STEM}_d) + \gamma_2(F_v \times \text{Post}_t) \\ &+ \gamma_3(\text{STEM}_d \times \text{Post}_t) \\ &+ \theta_{DDD}(F_v \times \text{STEM}_d \times \text{Post}_t) + \delta_c + \delta_t + \varepsilon_{cdtv}, \end{aligned} \tag{4}$$

where W_{cdtv} denotes the ACS-weighted number of workers employed in STEM occupations in commuting zone c, degree group d, year t, and worker group v. The indicator $F_v = 1$ for likely F-1 workers and $F_v = 0$ for U.S. citizens, including naturalized citizens. The indicators STEM_d and Post_t retain their definitions from the baseline specification. The terms δ_c and δ_t denote commuting-zone and survey-year fixed effects, respectively.

The coefficient of interest, θ_{DDD}, measures the degree-based difference-in-differences among likely F-1 workers relative to the corresponding difference among U.S. citizens. A positive coefficient indicates that, within STEM occupations, the post-reform increase in STEM-degree workers relative to non-STEM-degree workers is larger among likely F-1 workers than among U.S. citizens. In other words, a positive θ_{DDD} implies that the OPT extension helps retain foreign STEM graduates in STEM occupations beyond what can be explained by a general increase in demand for STEM degree holders.

6 Results

6.1 Employment Changes by Worker Group and Occupation

Following the OPT extension, employment in STEM occupations shifts toward STEM graduates among likely F-1 workers. Column (1) of Table 2 shows a positive and significant relative employment gain for STEM graduates compared with non-STEM graduates. Using Poisson pseudo-maximum

Table 2: Degree-Based Differences in Employment after the OPT Extension

	Likely F-1 workers		U.S. citizens	
	(1)	(2)	(3)	(4)
Occupation group	STEM OCC	Non-STEM OCC	STEM OCC	Non-STEM OCC
STEM degree	0.53^{**}	-0.44^{**}	0.06	-1.16^{***}
	(0.21)	(0.22)	(0.09)	(0.09)
STEM degree × Post	0.90^{***}	−0.13	0.13	0.21^{*}
	(0.27)	(0.29)	(0.12)	(0.12)
Commuting-zone FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	1,248	1,248	1,248	1,248

Notes: Each column reports a separate OLS regression. The dependent variable is the inverse hyperbolic sine of the number of workers in a commuting-zone–degree–year cell. The sample covers 2012–2023 in the 52 commuting zones. Post equals one in 2017–2023. U.S. citizens include naturalized citizens. Standard errors are in parentheses. The common post indicator is absorbed by year fixed effects and is not reported separately. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

likelihood, I estimate that among likely F-1 workers in STEM occupations, the ratio of employment for STEM graduates to employment for non-STEM graduates is about 125 percent higher after the OPT reform than before (Appendix B, Table B1). In non-STEM occupations, column (2) shows little evidence of a change in relative employment between the two degree groups.

Among U.S.-citizen graduates, column (3) shows little evidence of a shift toward STEM-degree holders within STEM occupations. Instead, employment rises for STEM graduates relative to non-STEM graduates within non-STEM occupations (column 4).

Figure 3 illustrates these before-and-after patterns across all four worker-group and occupation subsamples, plotting mean employment in IHS scale in 2012–2016 and 2017–2023 by degree field. In the top-right panel (likely F-1 workers in STEM occupations), employment rises for STEM degree holders after the reform while declining for non-STEM degree holders, noticeably widening the gap between the two groups. By contrast, in the top-left panel (likely F-1 workers in non-STEM occupations), employment for both degree groups moves nearly in parallel. The bottom two panels show different patterns among U.S. citizens: in STEM occupations (bottom-right), employment of STEM degree holders increases only slightly relative to non-STEM degree holders, while in non-STEM occupations (bottom-left), employment of STEM degree holders remains relatively flat as that of non-STEM degree holders declines modestly.

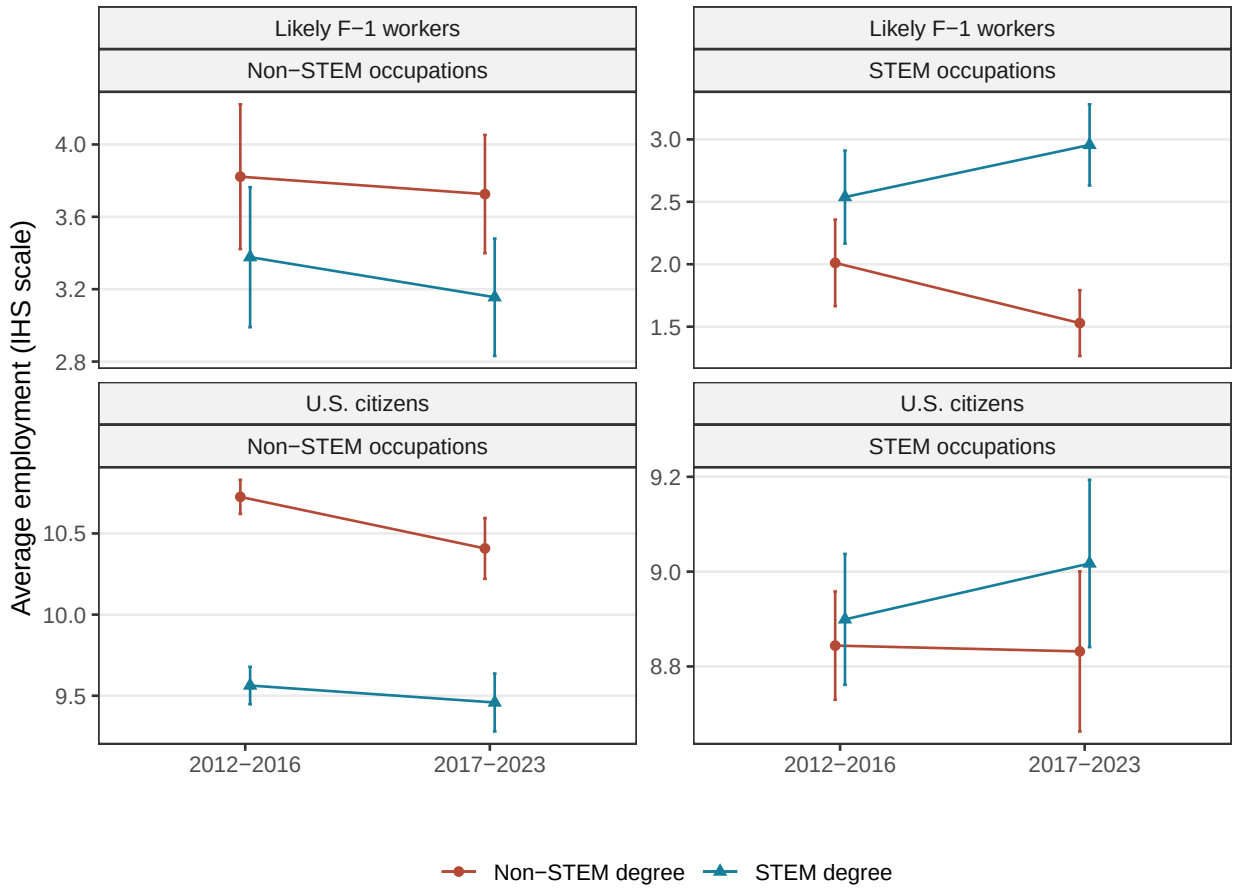


Figure 3: Employment before and after the Reform by Worker Group and Occupation

Notes: Each point in each figure shows the average of IHS-transformed number of workers across commuting-zone, degree-field, and year cells. Error bars are 95 percent confidence intervals for these descriptive means. Before corresponds to the years 2012–2016; after corresponds to the years 2017–2023.

6.2 Comparing Likely F-1 Workers and U.S. Citizens in STEM Occupations

Table 3 directly compares the employment shifts in columns (1) and (3) of Table 2. Within STEM occupations, the relative employment increase for STEM graduates compared with non-STEM graduates is larger among likely F-1 workers than among U.S. citizens. The triple difference is positive and significant at the 5 percent level. I also estimate this triple difference-in-difference specification using Poisson pseudo-maximum likelihood to interpret the size of this difference in percentage terms. The result shows that the ratio of STEM to non-STEM graduate employment among likely F-1 workers reaches nearly twice the level it would reach if it grew at the same rate as the corresponding ratio among U.S. citizens. The triple difference is positive and significant at the 1 percent level (Appendix B, Table B1). This larger relative increase among likely F-1 workers suggests that their

Table 3: Likely F-1 Workers and U.S. Citizens in STEM Occupations

Dependent variable	IHS(W_{cdtv})
Likely F-1	-6.83^{***}
	(0.17)
STEM degree	0.06
	(0.17)
Likely F-1 × STEM degree	0.47^{**}
	(0.24)
Likely F-1 × Post	-0.47^{**}
	(0.22)
STEM degree × Post	0.13
	(0.22)
Likely F-1 × STEM degree × Post	0.77^{**}
	(0.31)
Commuting-zone FE	Yes
Year FE	Yes
Commuting zones	52
Observations	2,496
R^2	0.786

Notes: This table shows the results for the triple difference-in-difference analysis for STEM occupations. A cell is defined by commuting zone, degree group, year, and worker group (likely F-1 vs. U.S. citizen). The dependent variable is the inverse hyperbolic sine of the number of workers in each cell. The sample uses the same 52 commuting zones and 2012–2023 period as Table 2; Post equals one in 2017–2023. Standard errors are in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

post-reform gains are not simply driven by a general rise in demand for STEM skills, consistent with the OPT extension helping foreign STEM graduates remain in STEM jobs.

7 Event-Study Analysis

In this section, I estimate an event-study model to check whether the two degree groups follow parallel trends before the 2016 reform and how their employment gap changes from year to year afterward. For each worker group and occupation, I estimate

$$\text{IHS}(W_{cdt}) = \alpha + \beta \text{STEM}_d + \sum_{\substack{y=2012 \\ y \neq 2015}}^{2023} \theta_y(\mathbf{1}\{t = y\}\text{STEM}_d) + \delta_t + \delta_c + \varepsilon_{cdt}. \tag{5}$$

where $\mathbf{1}\{t = y\}$ is an indicator for survey year y and all other variables are as defined in equation (3). I omit 2015, the year just before the reform, as the reference year. Because the regression includes

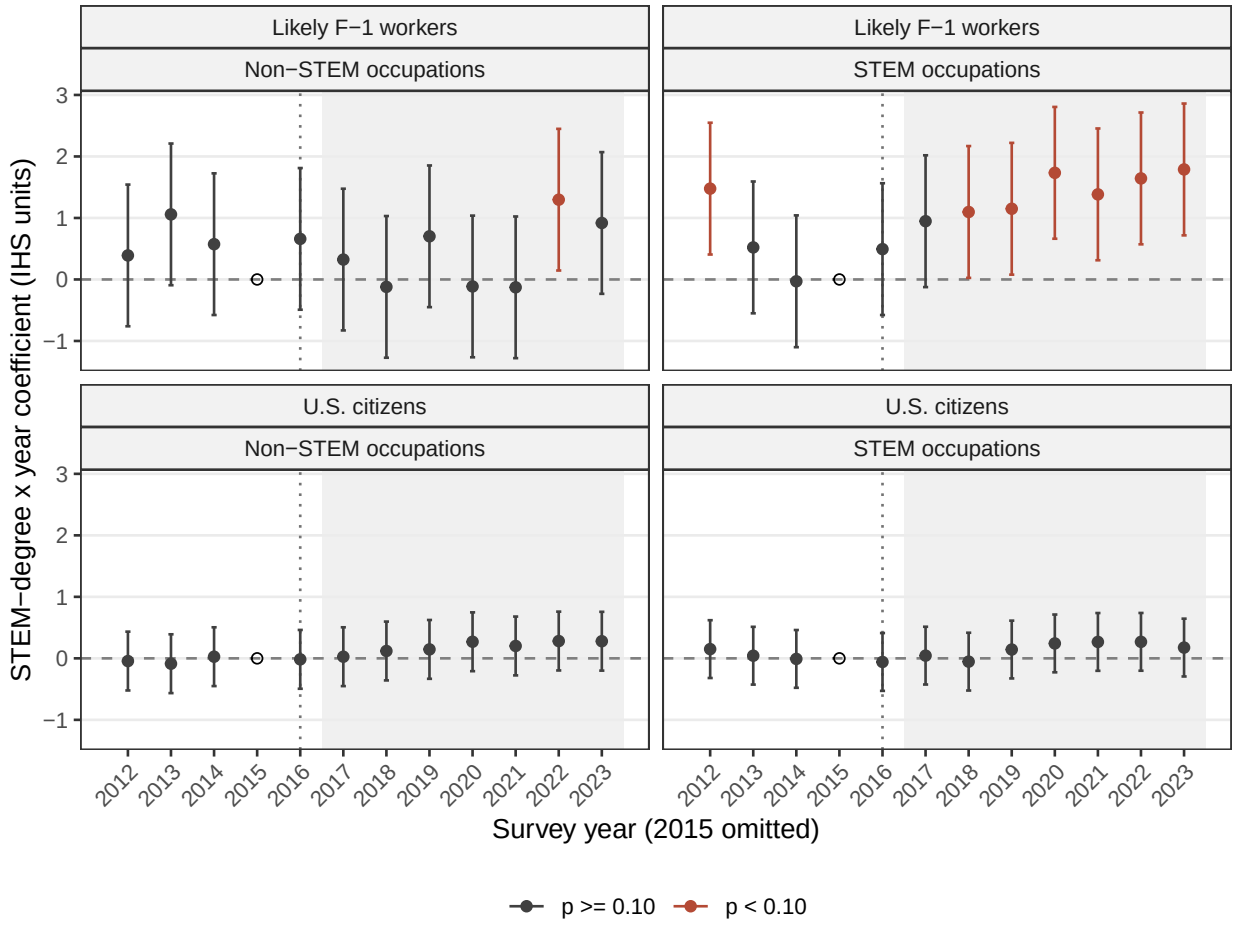


Figure 4: Event Study

Notes: The same 52 commuting zones are used over 2012–2023. The omitted year, 2015, is shown as an open point at zero. Bars are 90 percent confidence intervals based on standard errors; red points indicate $p < 0.10$. The dotted line marks the 2016 reform and shading indicates the post period, 2017–2023. Each panel is estimated separately with year and commuting zone fixed effects and a STEM-degree main effect.

the main effect STEM_d, each coefficient θ_y captures the difference in employment between STEM and non-STEM degree holders in year y relative to that gap in 2015.

Figure 4 plots the estimated coefficients θ_y and their 90 percent confidence intervals for each of the four subsamples. Looking first at likely F-1 workers in STEM occupations (top-right panel), the coefficient in 2012 is positive and statistically significant, which may reflect lingering adjustments from the earlier 2008 OPT extension. However, the estimate drops to 0.52 in 2013 and −0.03 in 2014, neither of which is statistically different from zero. Thus, in the three years leading up to the 2016 reform (2013–2015), there is no evidence of a pre-existing upward trend in the employment gap between STEM and non-STEM degree holders.

After the reform takes effect in 2016, the estimated gap in the top-right panel begins to widen. The coefficients in 2016 and 2017 are positive though not yet statistically significant at the 10 percent level. From 2018 through 2023, the estimates become larger and statistically significant in every year, ranging from 1.10 to 1.79 IHS units. Together with the flat pattern in 2013–2015, this gradual buildup indicates that the post-reform gains among likely F-1 STEM graduates represent a new divergence following the 2016 extension rather than the continuation of an earlier trend.

By contrast, the other three panels show little systematic change after 2016. Among likely F-1 workers in non-STEM occupations (top-left panel), the post 2016 OPT extension coefficients remain close to zero and statistically insignificant in all years except 2022. Similarly, in both panels for U.S. citizens (bottom-left and bottom-right), the estimates stay flat near zero and are statistically insignificant throughout the sample period.

8 Conclusion

This paper examines whether extending post-graduation work authorization helps retain foreign STEM graduates in STEM occupations in the United States. Exploiting the 2016 OPT reform, which increased the maximum work authorization period for eligible F-1 STEM graduates from 29 to 36 months while leaving the 12-month period for non-STEM graduates unchanged, I analyze employment changes across 52 commuting zones using ACS microdata from 2012 to 2023. Within STEM occupations, I find that employment rises significantly more for likely F-1 workers with STEM degrees than for those with non-STEM degrees after the reform, corresponding to a 125 percent increase in the relative employment ratio. No comparable shift appears among likely F-1 workers in non-STEM occupations, and a triple-difference comparison confirms that the relative gain in STEM occupations is significantly larger among likely F-1 workers than among U.S. citizens. Event-study estimates further show that this employment gap is flat in the years just before the reform (2013–2015) and widens steadily from 2018 through 2023.

Beyond the direct retention of foreign graduates, the results point to broader occupational sorting within local labor markets. Among U.S. citizens working in non-STEM occupations, I find suggestive evidence that employment of STEM degree holders increases relative to that of non-STEM degree holders over the same period. Consistent with comparative advantage across technical and

communication-intensive tasks, foreign STEM graduates increasingly concentrate in STEM occupations while domestic STEM graduates sort into non-STEM roles. Taken together, these findings indicate that longer post-graduation work authorization is an effective policy tool for retaining foreign-educated STEM talent in the U.S. STEM workforce. Because the ACS does not report visa status or advanced-degree fields, my analysis focuses on bachelor's degree holders and measures group-level employment across local labor markets; using administrative data to track individual transitions from OPT to longer-term work visas and to study master's and doctoral graduates remains an important direction for future research.

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A Triple-Difference Analysis across Occupations

Among likely F-1 workers, let S_j indicate a STEM occupation. The supplementary specification is

$$\begin{aligned}\text{IHS}(W_{cdtj}) = \alpha &+ \beta_S S_j + \beta_D \text{STEM}_d + \gamma_{SD}(S_j \text{STEM}_d) \\ &+ \gamma_{SP}(S_j \text{Post}_t) + \gamma_{DP}(\text{STEM}_d \text{Post}_t) \\ &+ \theta_{occ}(S_j \text{STEM}_d \text{Post}_t) + \delta_t + \delta_c + \varepsilon_{cdtj}. \end{aligned} \tag{6}$$

The coefficient θ_{occ} compares the degree-based difference-in-difference in STEM occupations with that in non-STEM occupations for likely F-1 workers. Table A1 shows that, after the OPT reform, the number of STEM-degree workers relative to non-STEM-degree worekrs increases significantly more among STEM occupations than among non-STEM occupations.

Table A1: Occupational Comparison among Likely F-1 Workers

Dependent variable	IHS(W_{cdtj})
STEM occupation × STEM degree × Post	1.02^{***}
	(0.40)
Commuting-zone FE	Yes
Year FE	Yes
Observations	2,496
R^2	0.409

Notes: A cell is defined by commuting zone, degree group, year, and occupation group. The dependent variable is the inverse hyperbolic sine of the number of workers. The sample covers 2012–2023 in the same 52 commuting zones as Table 2. Post equals one in 2017–2023. The reported coefficient is the difference between the degree-based difference-in-difference in STEM and non-STEM occupations. Standard errors are in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

B Robustness to Poisson Pseudo-Maximum Likelihood Estimation

As a robustness check, I re-estimate the main difference-in-differences result in column (1) of Table 2 and the triple difference comparing likely F-1 workers with U.S. citizens in Table 3. I use Poisson pseudo-maximum likelihood to estimate both models directly from worker counts, including zero counts. I use Poisson pseudo-maximum likelihood because it allows me to work directly with the ACS-weighted employment counts, including cells with zero workers and cells with fractional counts due to weighting (Santos Silva and Tenreyro, 2006). Lastly, I use the same samples and fixed effects as in the main analysis and cluster standard errors by commuting zone.

Table B1: Poisson Pseudo-Maximum Likelihood Estimates for the Main DD and Triple Difference

Specification	(1) Main DD	(2) Triple difference
Worker group	Likely F-1	Likely F-1 and U.S. citizens
Occupation	STEM OCC	STEM OCC
STEM degree × Post	0.810^{***}	—
	(0.118)	
Likely F-1 × STEM degree × Post	—	0.670^{***}
		(0.126)
Commuting-zone FE	Yes	Yes
Year FE	Yes	Yes
Observations	1,248	2,496

Notes: Each column reports a separate Poisson pseudo-maximum likelihood regression. Column (1) corresponds to Table 2, column (1); column (2) corresponds to Table 3. Samples cover 2012–2023; Post equals one in 2017–2023. Zero-count cells are retained. Standard errors clustered by commuting zones are in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.