Did OPT Policy Changes Help Steer and Retain Foreign Talent into STEM?

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Abstract

Academia and the public media have emphasized the link between STEM majors and innovation, as well as the need for STEM graduates in the U.S. economy. Given the proclivity of international students to hold STEM degrees, immigration policy may be used to attract and retain high-skilled STEM workers in the United States. We examine if a 2008 policy extending the Optional Practical Training (OPT) period for STEM graduates affected international students' propensities to major in a STEM field. Using data from the National Survey of College Graduates, we find that, relative to foreign-born U.S. college graduates who arrived on other visas allowing them to work, foreign-born students who first came to the United States on student visas became 18 percent more likely to major in STEM following the OPT policy change. We also find that the OPT policy change increased the likelihood of adding a STEM major among students who had listed a non-STEM major as their first major, as well as the propensity to pursue a master's degree in a STEM field among students whose bachelor's degree was in a non-STEM field.

JEL Codes: F22, J61, J68

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1. Introduction

For quite some time, the link between STEM majors and innovation, as well as the growing need for STEM graduates in the U.S. economy, have been repeatedly underscored in academia and the public media. Given the proclivity of international students, relative to native ones, to get a degree in a STEM field (NSF Science and Engineering Indicators, 2012), immigration policy might be used as a tool to retain high-skilled immigrants educated and trained in the United States in these fields. One such policy is the extension of the Optional Practical Training (OPT) period for foreign-born STEM graduates who received their degree from a U.S. university. This paper explores the impact of this policy change on the likelihood that international students in the United States choose STEM fields as their major.

OPT is a period during which international students in the United States are allowed to temporarily work on their student visas with the intent of gaining practical training to complement their education. While, in general, OPT lasts for one year, undergraduate and graduate students with STEM degrees were granted a 17-month extension starting in 2008; thus, allowing them to work in the United States for a total of 29 months on their student visas.[1]

The OPT extension may have made pursuing a STEM degree in the United States more attractive to students for several different reasons. First, students might benefit from an extended training period during which they can develop professional contacts, find a good job match and plan their next career move. Second, U.S. employers may be more likely to hire international candidates knowing they have more time to evaluate the prospective employee's performance before sponsoring an H-1B visa, the temporary work visa most often used by U.S. employers when

[1] The initial extension was extended to 24-months in 2016. Our data does not allow us, however, to examine this later extension. For more details on both extensions, see: https://studyinthestates.dhs.gov/stem-opt-extension-overview.

hiring highly skilled foreign-born workers. Perhaps most importantly, given that in recent years H-1B visas in the private sector were awarded by lottery, the extended OPT period allows employers to apply for an H-1B for a given job candidate in multiple years, before the worker must leave the country.[2]

We use data from the 2003, 2010, 2013, and 2015 National Survey of College Graduates (NSCG) –a representative dataset of the college-educated population in the United States– to explore the effectiveness of the 2008 OPT extension in attracting foreign-born students to pursue STEM degrees in the United States. We focus on individuals ages 16 to 64, who obtained their highest degree in the United States, and who came to the United States on an F-1 student visa or on another type of visa that allowed them to work.

We rely on a difference-in-difference approach that gauges how the OPT extension affected international students' decision to pursue a STEM major. Specifically, we compare pre vs. post-OPT extension changes in the propensity to choose a STEM degree of foreign-born U.S. college graduates who are likely to have used the OPT extension (*treatment* group), to changes in the propensity exhibited by other foreign-born U.S. college graduates authorized to work when they arrived to the United States (*control* group). Because we are examining changes in students' choice of a STEM degree, we look at changes in their enrollment practices before and after the policy change. We approximate enrollment years based on people's graduation years. Our treatment group consists of individuals who first came to the United States (for more than six months) on a student visa. Since OPT allows international students to work while on a student

[2] H-1B visas are generally awarded on a first come, first served basis up until the yearly cap has been reached. Starting in 2004, the H-1B visa cap has been reached every single year. To maximize the chances that the visa is awarded, firms typically apply for the visas at the earliest possible date—April 1st. In many years, the cap has been reached in the first week, and in these cases, all visas were awarded by lottery. By extending their OPT period, STEM graduates now enjoy multiple chances to apply for the scarce H-1B visas.

visa, this is the group that would be directly affected by changes in the OPT policy. The control group includes the foreign-born who first came to the United States for more than six months on a permanent or temporary visa that allowed them to work. While it is possible that they switched to a student visa while pursuing their degrees in the United States, they may never have had a student visa and, most likely, might have been able to easily work in the United States post-graduation, regardless of the OPT policy.[3] Our analysis thus tests whether the foreign-born in our treatment group became more likely than the foreign-born in the control group to major in STEM if they enrolled in their field of degree after the 2008 policy change.

Our findings reveal that the OPT extension raised the propensity of having a STEM major by about 18 percent for those in our treatment group relative to those in our control group. To provide evidence that this baseline estimate can be interpreted as causal, we test for pre-trends, make changes to our control and treatment groups, and explore the robustness of our estimates to the addition of several control variables to our model. All the checks support the interpretation of the OPT extension impacts on international students' STEM major choices as causal. Most of the impact originates from students with a terminal master's degree, for whom the likelihood of having a STEM major rose by 33 percent. We also explore which STEM fields were most affected by the OPT policy change, and find that the OPT extension increased the engineering workforce in the United States more than any other STEM field.

Given that the OPT extension made STEM degrees more attractive to international students considering studying a STEM major, as well as STEM degree holders more attractive to potential

[3] Examples of temporary work visas include H-1B, L-1A, L-1B H-1B1, E-3 and TN visas. The diversity visa is an example of a permanent work visa. While some individuals in our control group could have benefitted from the extended OPT if they had switched from a temporary visa to a student visa, including these individuals in the control group only makes it more difficult for us to find an impact of the policy.

employers, the policy may have increased foreign-born STEM majors in the United States through several mechanisms. First, it may have induced those students already studying in the United States, or determined to study in the United States, to choose a STEM degree as opposed to a non-STEM degree. It is also possible, however, that the policy change induced those already determined to pursue a STEM degree to pursue these studies in the United States, as opposed to studying in their home countries or studying abroad elsewhere. This too would increase the share of STEM graduates in the United States after the change in OPT policy. Another possibility is that the policy simply decreased the amount of return migration among STEM students relative to non-STEM students if STEM majors became more likely to get a job offer and eventually win H-1B lotteries.

Because of data restrictions, we are not able to distinguish among all the mechanisms driving our findings –all of which could be taking place simultaneously. Instead, we focus on the net effects of the policy change, while providing suggestive evidence of some of the potential mechanisms responsible for those effects. Specifically, we consider whether the policy induced people who appear only marginally committed to pursuing a STEM degree, to graduate with a STEM degree. To that end, we first look at whether the OPT extension induced double majors with a non-STEM field listed as their first major to hold a second major in a STEM field. We find that among international students with two master's degrees, the propensity to double major in STEM when their first major was in a non-STEM field increased 1.7 times. Furthermore, the OPT extension appears to have induced many non-STEM B.A. majors to pursue a master's degree in STEM, making such a transition 1.1 times more likely. These results might be interpreted as suggestive evidence of the OPT extension inducing "marginal" STEM majors to pursue a STEM degree, in addition to potentially inducing determined STEM majors to pursue their studies in the United States, and contributing to more STEM majors to stay in the United States after graduation.

The remainder of the paper is organized as follows. In Section 2, we provide some background on the subject of study. In Section 3, we discuss the data and summary descriptive statistics. In Section 4, we present the methodology, and this is followed by the main results in Section 5. Additional educational impacts of the OPT extension are considered in Section 6. Section 7 concludes the study.

2. Background

Optional Practical Training (OPT) is a type of work authorization that allows international students to gain work experience in their field of study, for generally up to 12 months, while on their F-1 student visas. Because OPT is viewed as a type of training, the temporary employment must be directly related to the student's academic major, regardless of whether it is used while students are completing their studies or after graduation.[4]

On April 2, 2008, students with a STEM degree became eligible for a one-time 17-month extension of their OPT periods. Before applying for the extension, international students must first use the regular (12-month) period of OPT. While students can apply for a regular OPT without a job offer, a current or prospective employer must be specified as part of the STEM-extension application. STEM-extension employers must be part of the E-Verify program. The extension also allows for an additional 30 days of unemployment, beyond the 90 days granted to all students

[4] Before becoming eligible for OPT, a student must be registered as a full time student for at least one academic year at an accredited U.S. college or university. Any OPT used while students are completing their degrees is deducted from the generally 12-month OPT period available after graduation. After starting OPT, students can change jobs, but cannot be unemployed in between these jobs for more than 90 days. Students with multiple majors can work in jobs related to each of the fields, but still cannot work more than the 12 months for each degree level. A student can use separate 12-month OPT periods for different levels of degrees: one for a bachelor's degree, another for a master's, and another for a doctoral degree. For more details, visit: https://www.uscis.gov/working-united-states/students-and-exchange-visitors/students-and-employment/optional-practical-training.

on OPT. Using administrative data on international students studying in the United States, Murat (2016) finds that the OPT extension lengthened the amount of time STEM degree holders remained on their student visas. We contribute to this work by examining whether the STEM extension influenced decisions to choose a STEM field in the United States in the first place.

The STEM-extension policy is likely to have mechanically increased the share of STEM majors living in the United States (relative to the share of non-STEM majors) because it allowed STEM majors to remain in the United States for more years. This surely increased the likelihood that STEM graduates were able to obtain more long-term work visas also in a rather mechanical way. More interestingly, however, the policy may have led to changes in the choice of majors made by the students. First, among students who knew they wanted to study in the United States, the easier transition for STEM graduates to the labor market may have increased their likelihood of pursuing a STEM degree instead of a non-STEM degree. Second, among students who knew they wanted to pursue a STEM degree, an easier labor market transition in the United States may have increased their likelihood of coming to the United States to study as opposed to doing so in their home countries or in a third country. Young adults are often unsure about *what* to study and *where*. The OPT policy change may have simultaneously induced more foreign-born students to study a STEM field and to pursue that degree in the United States. In this section, we discuss how our paper contributes to the literature on college major choices, as well as to the literature on the choice to study abroad.

A rapidly expanding literature has examined the determinants of college major choice—specifically, the choice of a STEM field as a major. Theory posits that this decision is made under uncertainty by weighing expected costs and benefits. The costs of pursuing a STEM degree depend both on the student's level of preparation before starting the program, as well as on the support received while completing the course work. For example, having completed AP classes in STEM fields in high school and having higher SAT scores seem to increase persistence in STEM fields (Griffith 2011; Price 2011; Rask 2011).[5] College grades in introductory classes are also strong predictors of STEM persistence (Ost 2011; Rask 2011). Interestingly, students in highly selective institutions that have larger graduate programs and spend more money on research are less likely to persist in STEM fields (Griffith 2011), presumably because faculty do not have the time and resources to devote to undergraduate education and mentoring.

Expectations about future careers also influence the choice of college major. Students' decisions to pursue engineering careers tend to be sensitive to career prospects in the engineering field (Ryoo and Rosen 2004). While both males and females tend to consider future labor market issues when making college major choices, males tend to care more about the pecuniary returns to working in different fields, whereas females tend to place more weight on nonpecuniary attributes, such as enjoying the work and the ability to reconcile work and family (Zafar 2013). For international students studying in the United States, the expected ability to work in the United States after graduation is also likely to play a strong role in their choice of college major. The 17-month extension of the OPT for STEM students from 2008 may have induced some of the students at the margin of choosing a STEM degree, to choose the STEM major.

The OPT extension may also have increased the number of STEM students from abroad choosing to study in the United States. Rosenzweig (2006) puts forth two main models of the decision to study abroad. The *constrained domestic schooling* model emphasizes high returns to skill in home countries, combined with a scarcity of home country institutions of higher education able to produce that skill. The *migration model*, in contrast, points to a higher return to skill in the

[5] Only about half of the freshmen who enter college already planning to pursue a STEM major graduate with a STEM degree within six years (Ehrenberg 2010).

host country than in the home country as studying in the host country opens doors for future employment in the higher wage host country. Using data to test the predictions of both of these models, he finds the evidence most consistent with the migration model. If, indeed, the main purpose of studying in the United States is to gain access to the U.S. labor market, then a policy facilitating the school-to-work transition should increase the propensity of students targeted by the policy (namely, those with the interest and ability to study a STEM field) to pursue higher education degrees in the United States.[6]

In line with this assessment, Bound *et al*. (2015) conclude that a U.S. degree is an important pathway to the U.S. IT labor market. They point to the very large wage premium in the U.S. IT labor market (Clemens 2013), and suggest that U.S. employers are more likely to choose job market candidates with U.S. credentials because they are more familiar with U.S. institutions. Given the large share of international students who stay in the United States after completing their degrees to work (Bound *et al*. 2015),[7] and the fact that about a third of international students enter the U.S. labor market through the OPT program (Bound *et al*. 2015), their choice of a STEM field might be reasonably sensitive to OPT policy changes.

There is a growing literature showing that students consider immigration policy when deciding whether to pursue their degrees at U.S. colleges and universities. To examine the impacts of a newly binding H-1B visa cap in 2004, several studies exploit the fact that trade agreements grant citizens from five countries (Canada, Mexico, Chile, Singapore, and Australia) access to work visas that are close substitutes to the H-1B, but that do not have binding caps (Amuedo-

[6] Bound *et al*. (2016) describe four main factors driving the variation in the number of foreign-born students studying at U.S. universities as follows: the affordability of U.S. tuition, the home country's educational preparation of students, the availability of quality institutions of higher education in home countries and, most importantly for our study, the value of accessing the U.S. labor market.

[7] Between 1999 and 2009, about a half of each graduating class of international students switched from student (F) visa status to H-1B status (Bound et al. 2014).

Dorantes and Furtado 2016, Kato and Sparber 2013, Shih 2016). Shih (2016) shows that the number of international students from countries that lacked access to these alternative work visas dropped after 2004 relative to the number of students from the five countries with access to alternative work visas. In the seminal paper using this identification strategy, Kato and Sparber (2013) show that, after the reinstatement of the lower visa cap, SAT scores of foreign-born students without access to substitute visas decreased relative to the scores of students from countries with access to alternative work visas. This may be because the students of higher ability are more likely to consider future prospects of working in the United States when making the decision to study abroad. While the 2004 cut in the number of available H-1B visas impacted college-educated workers across all fields, the 2008 OPT extension made the transition to the U.S. labor market easier only for students with U.S. STEM degrees. Thus, we may expect an increase in the number of STEM students choosing to study in the United States.

Our focus will be on evaluating if the OPT extension for STEM graduates appears effective at increasing the number of foreign-born U.S. STEM degree holders. We also hypothesize about the channels through which the observed impact might be taking place, such as the ability to attract future STEM students to study in the United States, the ability to induce international students to choose to choose a STEM field, and/or the increased likelihood that foreign-born STEM students stay in the U.S. long term. We provide empirical evidence of the policy inducing some international students, who are likely to have otherwise made a different field choice, to choose a STEM degree. We view this as suggestive evidence that the OPT extension might have been successful in raising the share of international students opting for STEM fields.

3. Data and Descriptive Statistics

We use data from the 2003, 2010, 2013, and 2015 National Survey of College Graduates (NSCG). For the purpose of our analysis, we focus on foreign-born individuals ages 16 to 64, who came to the United States on an F-1 student visa or on a visa, temporary or permanent, that allowed them to work. We drop from the sample those who first arrived as temporary residents, as dependents, and those that arrived on other temporary visas. We also drop those that graduated before the year 1995 and the very few in the sample who were not living in the United States at the time of the survey. Because OPT and its extension require a U.S. degree and are most often used at the conclusion of a student's F-1 visa, we further focus on the foreign-born who received their terminal degrees in the United States.

The NSCG collects information on up to 142 majors, which we categorize into two field groups: STEM and non-STEM, according to the STEM Designated Degree Programs list provided by U.S. Immigration and Customs Enforcement (ICE).[8] To identify the impact of the OPT policy change, we divide our sample into treatment and control groups based on whether they are likely to benefit from an OPT extension. Our treatment group consists of the foreign-born who first entered the United States on an F-1 student visa. Our control group is comprised of other foreign-born U.S. college graduates who first entered the United States with a temporary or permanent visa authorizing them to work in the United States. These individuals arrived as adults and received a degree from a U.S. college or university. However, because they first arrived with work authorization, they would benefit very little from the extended OPT time. In fact, in all likelihood, they may never have even held a student visa. They would, however, respond to any labor market shocks and trends in STEM fields, even those specific to the foreign-born, that are independent of OPT policy.

[8] See full list at https://www.ice.gov/doclib/sevis/pdf/nces_cip_codes_rule_09252008.pdf.

Table 1 provides some basic descriptive statistics of our sample. According to Panel A, the share of international students majoring in a STEM field is about twice as large for the foreign-born in our treatment group (52 percent) compared to their counterparts in the control group (25 percent). Those in the treatment group are also more likely to be male, married, and live in the South and North Central regions of the country than foreign-born students with access to alternative work visas. The racial and ethnic composition of both groups of international students also varies significantly. Asian students have a greater presence in the treatment group, whereas there is a greater share of whites, blacks and Hispanics among the foreign-born with access to work visas. Finally, the two groups also differ significantly with respect to their highest degree. Almost 80 percent of the individuals in the treatment group completed either a master's or a doctoral degree (57 percent indicate their highest terminal degree was a master's and for 21 percent it is a doctoral degree). In contrast, less than half of those in the control group have received a master's or doctoral degree (30 percent indicate having a master's degree as their terminal degree and 3 percent indicate having a doctoral degree).

Because our identification strategy relies on comparing treatment and control groups depending on whether they are likely to have enrolled in the field before or after the OPT policy change, Panel B further splits the sample according to whether individuals are likely to have enrolled prior to 2008.[9] As can be seen therein, the differences between treatment and control groups predated the change in the OPT policy, emphasizing the need to control for such differences in the regression analysis.

Figure 1 shows the share of our sample with a STEM major according to whether the individuals are in the control or treatment group and by whether their enrollment year was before

[9] We do not have detailed information on enrollment dates. Instead, as discussed in the next section, we estimate enrollment years based on graduation years.

or after the OPT extension in 2008. It is interesting to see how the share of international students with a STEM major had been dropping, regardless of their visa at entry, prior to the change in the OPT policy. In other words, the two groups exhibited similar pre-trends. However, while the share of international students with a STEM major continued to exhibit a similar trend after the change in the OPT policy if they first arrived in the United States with work authorization, the trend reversed for foreign-born students whose U.S. employment was bound by the H-1B visa. The share of them holding a STEM major started to trend upwards. As a result, Figure 1 is suggestive of the fact that the OPT extension might have contributed to raising the likelihood of pursuing a STEM major among international students.

4. Methodology

While enlightening, Figure 1 fails to account for a wide range of factors potentially responsible for the change in STEM field choices by whether the enrollment year is before or after the 2008 policy change. Therefore, we next examine the impact of the OPT extension more thoroughly by estimating the following benchmark model:

(1) $$Y_{i,v,e,t} = \alpha + \beta OPT_{v,e} + X_i\gamma + \delta_v + \delta_e + \delta_t + \varepsilon_{i,v,e,t}$$

where $Y_{i,v,e,t}$ equals 1 if foreign-born student *i* who entered with a visa status *v*, and who enrolled in calendar year *e*, has a terminal degree in a STEM field when observed in survey year *t*; otherwise, it equals 0.

Our key regressor, *OPT*, equals 1 if the individual is in our treatment group and if enrollment in the major likely occurred after the 2008 OPT extension. The variable equals zero otherwise. It is worth noting that, while the NSCG contains information on graduation years, it does not contain information on the date in which the individual chose her/his major. Therefore, we proxy for this date. We set it equal to two years prior to graduation date if the terminal degree is a B.A., master's or professional degree. It is set equal to five years prior to graduation if the terminal degree is a Ph.D.[10] The main coefficient of interest, β, thus gauges how the OPT extension might have impacted international students' proclivity to choose a STEM major when compared to their counterparts who initially arrived in the United States with a non-student visa allowing them to work.

The vector X accounts for a number of individual level characteristics likely affecting the type of major chosen, such as age, age squared, gender, race, ethnicity, marital status and highest educational degree. It also includes a series of country of origin fixed effects intended to capture idiosyncratic STEM preferences and preparation. The model also includes time-invariant fixed effects for the visa that the foreign-born used when they came to the United States for the first time (δ_v). We distinguish between three visa category statuses: (1) first entered on a permanent visa, (2) first entered on a temporary visa with work authorization; and (3) first came on a student visa.

To account for labor market opportunities faced by students during the year they enrolled in school, which could potentially impact their choice of major, we also include enrollment cohort fixed-effects (δ_e). Finally, equation (1) incorporates fixed effects for the year in which individuals were surveyed (δ_t). Standard errors are clustered on cells constructed based on whether the enrollment year was before vs. after 2008, visa status at first entry, and country of origin.

5. Did the OPT Extension Generate More Foreign-born STEM Degree Holders?

5.1 Main Findings, Robustness Checks and Heterogeneous Impacts by Highest Degree

Table 2 presents the results from estimating several specifications of the model in equation (1) that progressively include information on the highest degree held and a number of demographic

[10] Later on, we test the robustness of our findings to the use of different approximations of the field choice date, which we refer to as the "enrollment year".

controls. A few findings are worth discussing. First, the magnitude of the estimated coefficient of interest increases when we add controls for the highest degree completed. Adding further controls for demographic characteristics, such as age and marital status, yields estimated policy impacts that are slightly smaller, but not very different. Our final and preferred model, shown in column 3 of Table 2, suggests that the OPT extension significantly raised the likelihood of holding a STEM degree by 9.4 percentage points, or 18 percent, among those who first came to the United States on student visas.

Other traits, such as the student's gender, race, marital status and the highest degree held, also play an important role in raising her/his likelihood of holding a STEM degree. Notably, male foreign-born students are 18.5 percentage points (36 percent) more likely to have a STEM major than female foreign-born students. Additionally, those with a doctoral degree are 25 percentage points (49 percent) more likely to hold a STEM degree than their counterparts with a bachelor's degree. In contrast, older international students and those with a professional degree appear less likely to have a STEM degree. Specifically, those with professional degrees are 31 percentage points (60 percent) less likely than those with a bachelor's degree to hold a STEM degree.

We next explore the robustness of our findings in Table 2 to address potential concerns about identification and interpretation. If our estimated policy impacts are driven by changes in the characteristics of the foreign-born who come to the United States on work visas—as opposed to changes in majoring choices following the OPT policy change, our estimates should be very sensitive to even small changes in our control group. To explore this possibility, we consider two alternative control groups.

As described in more detail by Kato and Sparber (2013), free trade agreements allowed citizens from five countries to apply for close H-1B visa substitutes (Kato and Sparber 2013; Shih

2016; Amuedo-Dorantes and Furtado 2016). The visas are similar to the H-1B, but lack binding caps. Therefore, nationals of these five countries are not likely to be as dependent on the OPT extension to work in the United States after graduation, regardless of whether they first came on student visas. After all, they can do so under one of those alternative work visas. While sample sizes of nationals of these five countries are too small to exclusively use them as a control group, we can add them to our control group to see if the change affects our estimates. In column (1) of Table 3, we do so while replacing the visa and country of origin fixed effects with visa by country of origin fixed effects. Our findings remain practically unchanged.

Next, in column (2), we repeat our estimation, this time replacing our original control group with a much larger group –namely, similarly aged U.S.-born students who received their highest degree from a U.S. university after 1995. Doing so does not alter the sign or statistical significance of the estimated OPT policy impact in Table 2, although the magnitude of the effect decreases by a few percentage points. We view these results as quite convincing evidence that our main findings are not driven solely by characteristics and behaviors of the foreign-born who first came to the United States on work visas.

We next examine whether nationals of specific countries are driving our findings. We start by conducting the analysis excluding Chinese students from our sample. China is the top origin country of foreign students in the United States (Ruiz 2014). Hence, if a policy or institutional change in China drove Chinese students to specialize in STEM fields in the United States after 2008 for reasons unrelated to the OPT extension, we may be overestimating the impact of the OPT policy change. As seen in column (3) of Table 3, results remain very similar to those using our baseline sample.

Likewise, in column (4) of Table 3, we experiment with excluding Indian students from our sample. More than half of all H-1B visas are awarded to Indian nationals (Ruiz 2017). As such, they might be especially sensitive to small changes in OPT policy, as well as to home country conditions, when deciding whether to pursue a STEM degree in the United States. In column (5) of Table 3, we drop both Chinese and Indian respondents from our sample. While the estimate of interest remains only statistically significant at the 10 percent level as the sample size is cut down substantially, the magnitudes of the coefficients in columns (3) and (4) do not differ very much from our baseline estimate in the last column of Table 2.

We also consider the possibility that home country economic conditions, in nations other than China and India, are driving our findings. If, for example, per capita GDP was growing faster after 2008 in countries that typically send STEM students to study in the United States, return migration might have stepped up after graduation. In that case, our results may be reflective of the home country's economic environment and not, necessarily, of the OPT policy change.[11] To address this concern, we calculate the growth rate of per capita gross domestic product (GDP) for each enrollment year and country of origin and add it as a control to our baseline specification. As seen in column (6) of Table 3, adding the growth rate of per capita GDP does not appear to significantly alter our findings.

As discussed earlier on, we do not have precise information on the exact date individuals in our sample were deciding to pursue a STEM degree in the United States. As a last robustness check, we experiment with using an alternative proxy for the enrollment date. We set the date equal to 1 year prior to graduation if the terminal degree is a B.A. or a master's degree, two years

[11] Because STEM degree holders tend to be less sensitive to economic conditions than other college graduates (Altonji, Kahn, and Speer 2016), it is also possible that students from countries with smaller GDP growth rates are more likely to major in STEM.

prior to graduation if the terminal degree is a professional degree, and four years prior to graduation if the terminal degree is a Ph.D.[12] As shown in column (7) of Table 3, we continue to find that the OPT policy change raised the likelihood of choosing a STEM field by 8.6 percentage points (16.5 percent) among foreign-born students bound by the H-1B visa in order to work in the United States.

Next, given the significant role played by students' terminal degree in predicting their propensity to pursue a STEM degree in Table 2, we re-estimate our main model separately for respondents whose highest degree is a bachelor's, those with a master's and those with a doctoral degree. Table 4 shows the results from such an exercise. It is the group of international students with a terminal master's degree who appear 16 percentage points (33 percent) more likely to have pursued a STEM degree if they made their choice post-2008 and need an H-1B visa to work in the United States once their OPT expired. In other words, the OPT extension doubled the likelihood that terminal master's degree recipients were in STEM fields. Strangely, doctoral graduates are less likely to pursue a STEM degree following the OPT extension, but this effect is not statistically significant at conventional levels. Because so many doctoral recipients pursue careers in the academic sector, where the H-1B visa has not been capped since the year 2000 (Amuedo-Dorantes and Furtado 2016), their transitions to the U.S. labor market should not be as influenced by OPT policy extensions regardless of their incoming visas or country of origin.

5.2 Identification Checks

One of the main threats to our empirical approach is the potential for differential trends in the propensity of studying a STEM field among the international students in our treatment group

[12] The test is not performed with using earlier approximate enrollment dates due to few observations left in the treatment group.

and their foreign-born counterparts in the control group prior to the OPT policy change. To investigate if that should be a matter of concern in our case, we construct new indicators for those whose U.S. employment was bound by an H-1B visa and who enrolled one and two years prior to the OPT extension (that is, in 2006 and in 2007). We then include the placebo terms, along with the true policy indicator, in a model similar to the one in equation (1). If the impact shown in Table 2 predated the policy change, we would expect the placebo terms to have statistically significant estimated coefficients in the same direction of the OPT extension impact in Table 2.

The results of this test are documented in column (1), Panel A of Table 5. The estimated coefficients on the placebo terms are not statistically different from zero. As such, the impact of the OPT extension in Table 2 does not appear to have predated the policy change. Furthermore, despite the inclusion of the placebo terms, the true policy estimate continues to be statistically significant, suggesting an increased likelihood of choosing a STEM field by 19.5 percentage points or 38 percent.

To offer further reassurance that the results are not driven by a longer trend prior to the implementation of the visa cap, we restrict our sample to those enrolling in their majors during the pre-policy period, namely before 2008. Then, we create a time trend for the period under consideration, and interact it with a dummy variable equal to one for those who first came to the United States on student visas. Column (1) in Panel B of Table 5 displays the results from this exercise. Consistent with the parallel trends assumption, we find no evidence of a pre-existing trend driving our results, as the estimated coefficient on the interaction term is small and not statistically different from zero.

Given that students with terminal master's degrees drive our baseline estimates (see Table 3), we conduct the prior identification tests on our sample of master's degree holders. As shown in column (2) in Panels A and B of Table 5, we find no evidence of a pre-existing positive trend driving our findings. The placebo term is non-statistically different from zero. Importantly, the policy impact itself remains different from zero and positive. Likewise, when we restrict our sample to those individuals enrolling prior to 2008 and include an interaction term like the one in column (1) of that same Panel B, we find that the term is not statistically different from zero, hinting at the lack of predated impacts.

5.3 Heterogeneous Impacts by Field of Expertise

Finally, we explore if there are systematic differences in the impact of the OPT extension by type of STEM field. In other words, did specific STEM fields benefit from the OPT extension more than other fields? To answer this question, Table 6 displays the results from estimating equation (1), where the dependent variable is now the likelihood of having chosen a particular STEM field vs. any other field, regardless of whether the other field is in STEM. Specifically, we consider the following fields: computer and mathematical sciences, life and related sciences, physical and related sciences, social sciences, engineering, or science and engineering related fields.[13] According to the estimates in Table 6, the 2008 OPT extension appears to have made the largest impact on the likelihood that international students choose engineering degrees, making them 5 percentage points (26 percent) more likely to have chosen engineering as their degree major.

Since the increased tendency to choose a STEM field as a major following the OPT policy change is primarily observed among students with a terminal master's degree (see Table 4), we

[13] This last category includes the following fields: audiology and speech pathology, health services administration, health/medical assistants, health/medical technologies, medical preparatory programs, medicine, nursing, pharmacy, physical therapy and other rehabilitation, other health/medical sciences, computer teacher education, mathematics teacher education, science teacher education, social science teacher education, computer programming, data processing, electrical and electronic technologies, industrial production technologies, mechanical engineering-related technologies, other engineering-related technologies, architecture/environmental design, and actuarial science.

further zoom into this group to see their STEM field preferences. As shown in Table 7, the point estimates remain about the same, but because of changes in estimated standard errors, the STEM majors experiencing statistically significant changes following the OPT extension were life sciences and social sciences. Specifically, the propensity for M.A. students to choose the latter STEM fields as their major rose by 7 and 0.3 percentage points, respectively, following the OPT extension in 2008.

6. Did the STEM Extension Induce Students to Choose a STEM Major?

The change in OPT policy may have influenced students' decisions to pursue STEM degrees in the United States –either by increasing the likelihood of choosing a STEM field by students pursuing degrees in the United States or by increasing the likelihood of studying in the United States among students determined to specialize in STEM. While we cannot evaluate the extent to which the OPT extension might have attracted some international students interested in specializing in STEM fields to come to the United States, we can assess if the OPT policy change induced international students who had not pursued a STEM field before, to now do so. These are the very students who may be swayed to choose a STEM field by the change in immigration policy. Large impacts on these marginal students may be viewed as evidence that the policy change did induce some students to study a STEM field who may have otherwise not chosen STEM.

We have two ways to identify students at the margin of majoring in a STEM field. The first way is by focusing on students with double majors (or two master's degrees in different fields) who list a non-STEM field as their first major. A second way is by zooming on students with a bachelor's degree in a non-STEM field but a terminal master's degree in a STEM field, or with a Master's degree in a non-STEM field and a doctoral degree in a STEM field. We examine if the OPT extension induced more double majors consisting of a non-STEM first major and a STEM second major, as well as whether the extension induced more transitions into STEM fields for students pursuing a higher-level degree after having earned lower-level degrees in non-STEM fields.

6.1 Did the OPT Extension Induce a Second Major in STEM?

We start by restricting our sample to a subgroup of foreign-born U.S. college graduates who double majored and who report having earned their first major in a non-STEM field. Subsequently, using a model specification similar to the one in equation (1), we model the likelihood that their second major is in a STEM field. Hence, our new dependent variable takes the value 1 if the double-major graduate reports having chosen a STEM field for their second major, whereas it takes the value 0 if the graduate's second major was also in a non-STEM field. In the case of master's degree holders, a second major would consist of a second master's degree in a different field. Because of the very small number of graduates with multiple doctoral degrees, we only estimate the model with those with multiple bachelor or master's degrees. All other controls remain the same as in our prior specifications.

Columns (1) and (2) in Table 8 report the results from this exercise. The OPT extension appears to have induced students with two master's degrees to choose a STEM field as their field in their second degree. In particular, the new policy raised the propensity of international students with two master's degrees to choose a STEM field as their second master's degree by 11 percentage points –thus making the share of international M.A. students with a STEM field as their second degree approximately 1.7 times larger. However, we find no significant policy impacts on international students whose highest degree is a bachelor's degree. This is not surprising given the results in Table 3 showing that the individuals whose highest degree is a bachelor's degree do not appear very sensitive to the change in OPT policy in the first place.

6.2 Did the OPT Extension Induce Students with a non-STEM Bachelor's Degree to Choose a Post-Bachelor's Degree STEM Specialization?

Next, we examine if the change in the OPT policy induced students with a non-STEM bachelor's degree to pursue a master's degree in a STEM field, or students with non-STEM master's degrees to pursue a Ph.D. in a STEM field. Columns (3) and (4) in Table 8 distinguish across the various types of transitions –namely: (1) from a non-STEM B.A. to a STEM M.A., and (2) from a non-STEM M.A. to a STEM Ph.D. We do not explore the impact on transitions from a non-STEM B.A. into a STEM Ph.D. because they are quite rare. Finally, as before, we use a model specification similar to the one in equation (1), but changing our dependent variable to reflect the likelihood of each one of the transitions noted above. In column (3), the sample is limited to international students with a non-STEM B.A. who completed a master's degree. In column (4), we focus on international students with a master's degree in a non-STEM field who completed a Ph.D. In all instances, our dependent variable takes the value of one for the transition specified in the respective column heading, and zero otherwise.

According to the results in column (3) of Table 8, the OPT extension appears to have had a significant impact on the choice to transition from a non-STEM B.A. to a STEM master's degree. International master's degree holders with a non-STEM B.A. became 1.1 times more likely to choose a STEM field for their M.A. post-2008. However, the OPT extension does not appear to have significantly altered international students' propensity to transition from a non-STEM M.A. to a STEM doctoral degree.

In sum, the results in Table 8 suggest that the strongest influences of the OPT policy change may have been on students who many not have otherwise pursued a STEM degree. Taken together, we view the results as suggestive evidence that the OPT policy change had an effect on the field choice of students determined to study in the United States, in addition to also potentially affecting the choice of whether or not to study in the United States among students determined to pursue a STEM degree.

7. Summary and Conclusions

In this paper, we make a first attempt at examining some of the impacts of the 2008 extension of the Optional Practical Training (OPT) on international students' majoring choices. In part because the H-1B Visa Reform Act of 2004 made it significantly harder for most international students with an F-1 visa to secure employment in the United States, the OPT extension might have induced many foreign-born students to consider choosing a STEM field as a major. Using data from the 2003 through 2015 National Survey of College Graduates, we find that the OPT extension did raise the propensity of choosing a STEM field among international students by 18 percent, with engineering as the STEM field benefiting the most from the policy change.

Most of the aforementioned impact appears to be originating from students with terminal master's degrees, for whom the likelihood of choosing a STEM field rose by 33 percent. To examine the mechanisms driving this result, we explore whether we see large increases in the likelihood of pursuing STEM degrees among students who do not appear overly committed to studying only a STEM field. In particular, we look at whether the OPT extension induced some of international students to double major in a STEM field, even though their first major was in a non-STEM field. We find evidence that, indeed, that was the case. Specifically, among international students with a master's degree, the propensity to double major in a STEM field when their first major was in a non-STEM field increased 1.7 times. Furthermore, transitions from non-STEM B.A. majors to STEM Masters became 1.1 times more likely following the OPT policy change.

Overall, our results shed some light on the implications that changes in immigration policy can have on the majoring choices made by international students seeking training and possibly work experience in the United States post-graduation. Rothwell (2013) estimates that roughly 20 percent of all U.S. jobs require knowledge in a STEM field. In the same vein, it has been estimated that American companies will be hiring an additional 1.6 million workers in the next 5 years, with 945,000 of them requiring basic STEM literacy and 635,000 demonstrating advanced STEM skills (Business Roundtable & Change the Equation, 2014). Given the growing reliance of businesses on individuals with skills in STEM fields and the promotion of these fields in our educational system, increased awareness of the effectiveness, or lack of, of these policies in promoting those specialization choices is crucial.

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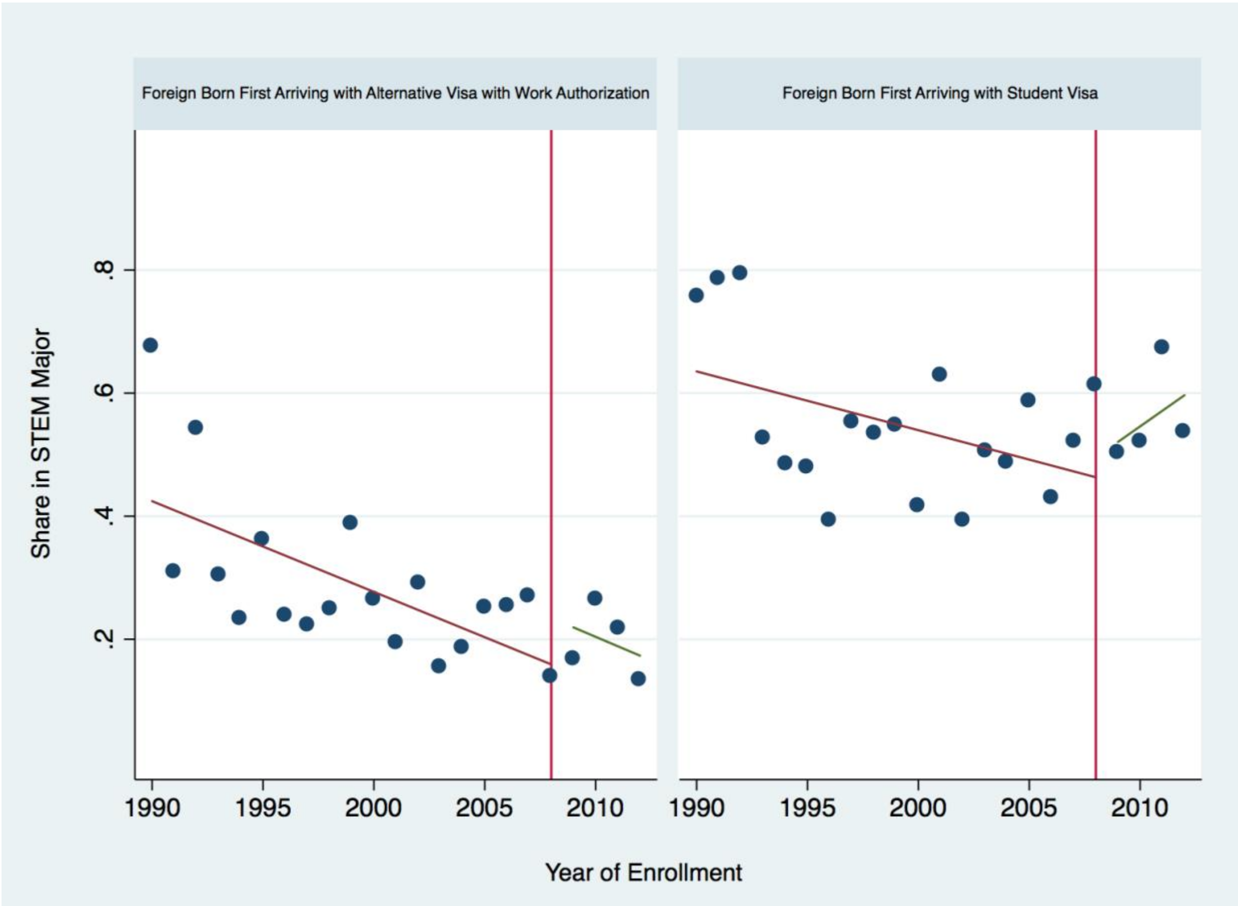
Figure 1. Share of STEM Majors by Entering Visa Type and Year of Enrollment



Notes: The sample consists of foreign-born individuals with a degree from a U.S. college or university ages 16 to 65, who either came to the United States on an F-1 student visa or on a visa, temporary or permanent, that allowed them to work.

Table 1: Descriptive Statistics

Panel A	**Full Sample Period**					
Sample	**Full Sample**		**First Arriving with Student Visa**		**First Arriving with Alternative Visa with Work Authorization**	
Statistic	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
STEM Major	0.36	0.48	0.52	0.50	0.25	0.44
Age	37.66	8.90	37.68	8.49	37.65	9.18
Male	0.51	0.50	0.61	0.49	0.44	0.50
White	0.21	0.40	0.19	0.39	0.22	0.41
Black	0.13	0.33	0.10	0.30	0.14	0.35
Asian	0.54	0.50	0.64	0.48	0.48	0.50
Hispanic	0.10	0.30	0.07	0.25	0.13	0.33
Married	0.65	0.48	0.70	0.46	0.62	0.49
Bachelor’s Degree.	0.43	0.49	0.19	0.39	0.59	0.49
Master’s Degree	0.41	0.49	0.57	0.49	0.30	0.46
Ph.D. Degree	0.10	0.30	0.21	0.40	0.03	0.17
Professional Degree	0.06	0.23	0.03	0.18	0.07	0.26
Highest Degree’s Graduation Year	2004	5.55	2004	5.59	2004	5.51
East	0.27	0.45	0.23	0.42	0.30	0.46
West	0.31	0.46	0.30	0.46	0.32	0.47
South	0.29	0.45	0.31	0.46	0.27	0.45
North Central	0.12	0.33	0.15	0.36	0.10	0.30
Observations	21,103		11,251		9,852	

Table 1 – Continued

Panel B	Pre-2008 Period						Post-2008 Period					
Sample	**Full Sample**		**First Arriving with Student Visa**		**First Arriving with Alternative Visa with Work Authorization**		**Full Sample**		**First Arriving with Student Visa**		**First Arriving with Alternative Visa with Work Authorization**	
Statistic	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
STEM Major	0.37	0.48	0.51	0.50	0.27	0.44	0.36	0.48	0.57	0.49	0.21	0.41
Age	38.97	8.43	39.21	7.93	38.80	8.76	32.70	8.91	31.68	7.93	33.36	9.44
Male	0.52	0.50	0.62	0.49	0.45	0.50	0.47	0.50	0.59	0.49	0.40	0.49
White	0.20	0.40	0.18	0.39	0.22	0.41	0.21	0.41	0.20	0.40	0.22	0.41
Black	0.11	0.32	0.11	0.31	0.12	0.33	0.17	0.38	0.09	0.28	0.23	0.42
Asian	0.57	0.50	0.64	0.48	0.51	0.50	0.46	0.50	0.62	0.48	0.35	0.48
Hispanic	0.10	0.29	0.06	0.24	0.12	0.32	0.13	0.34	0.09	0.28	0.16	0.37
Married	0.71	0.45	0.76	0.42	0.67	0.47	0.43	0.50	0.45	0.50	0.42	0.49
Bachelor’s Degree.	0.43	0.49	0.19	0.39	0.60	0.49	0.42	0.49	0.20	0.40	0.56	0.50
Master’s Degree	0.39	0.49	0.54	0.50	0.28	0.45	0.51	0.50	0.70	0.46	0.39	0.49
Ph.D. Degree	0.12	0.33	0.24	0.43	0.04	0.19	0.03	0.18	0.07	0.25	0.01	0.11
Professional Degree	0.06	0.24	0.03	0.17	0.08	0.28	0.04	0.19	0.04	0.19	0.04	0.19
Highest Degree’s Graduation Year	2002	4.43	2002	4.57	2002	4.33	2012	1.37	2012	1.38	2012	1.35
East	0.26	0.44	0.22	0.42	0.28	0.45	0.34	0.47	0.25	0.43	0.39	0.49
West	0.34	0.47	0.30	0.46	0.36	0.48	0.22	0.41	0.30	0.46	0.17	0.37
South	0.28	0.45	0.32	0.47	0.26	0.44	0.32	0.46	0.28	0.45	0.34	0.47
North Central	0.12	0.33	0.15	0.36	0.10	0.30	0.13	0.33	0.17	0.37	0.10	0.30
Observations	17,589		9,294		8,295		3,514		1,957		1,557	

Notes: The sample consists of foreign-born individuals with a degree from a U.S. college or university ages 16 to 65, who either came to the United States on an F-1 student visa or on a visa, temporary or permanent, that allowed them to work. We drop from the sample those who first arrived as dependents, and those that arrived on other temporary visas. All estimates are calculated using sample weights.

Table 2: Impacts of STEM Extension on STEM Major Choice – Dependent Variable: STEM Major

Model Specification	**(1)**	**(2)**	**(3)**
Student Visa * Enroll 2008 or Later	0.070 (0.044)	**0.110**** **(0.044)**	**0.094***** **(0.036)**
Age			-0.031*** (0.011)
Age Squared			0.000* (0.000)
Male			0.185*** (0.014)
Black			0.042 (0.067)
Asian			0.111*** (0.039)
Hispanic			0.037 (0.071)
Married			0.025 (0.015)
Master's Degree		-0.005 (0.028)	0.041 (0.028)
Ph.D. Degree		0.218*** (0.040)	0.248*** (0.036)
Professional Degree		-0.350*** (0.025)	-0.306*** (0.028)
Visa F.E.	Y	Y	Y
Enrollment Year F.E.	Y	Y	Y
Country of Origin F.E.	Y	Y	Y
Survey Year F.E.	Y	Y	Y
Observations	21,103	21,103	21,103
R-squared	0.216	0.256	0.313
Pre-2008 D.V. mean for those arriving with student visas	0.5084	0.5084	0.5084

Notes: Dependent variable: Highest degree being in a STEM field. See notes underneath Table 1 for details on sample. All regressions include a constant term. All estimates are calculated using sample weights. Standard errors are clustered on cells constructed based on whether the enrollment year was before vs. after 2008, visa status, and country of origin. *** p<0.01, ** p<0.05, * p<0.1

Table 3: Robustness Checks – Dependent Variable: STEM Major

Model Specification	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Add Five Substitute Visa Countries	**Use Native Students as Control**	**Exclude China from the Sample**	**Exclude India from the Sample**	**Exclude China and India from the Sample**	**Control for the Growth Rate of Per Capita GDP**	**Use Different Enrollment Year**
Student Visa * Enroll 2008 or Later	**0.101*** **	**0.062*** **	**0.083** **	**0.099*** **	**0.077* **	**0.114*** **	**0.086** **
	(0.029)	**(0.023)**	**(0.039)**	**(0.037)**	**(0.041)**	**(0.036)**	**(0.036)**
Age	-0.025**	-0.011***	-0.035***	-0.017*	-0.019*	-0.025**	-0.031***
	(0.010)	(0.002)	(0.012)	(0.010)	(0.011)	(0.011)	(0.011)
Age Squared	0.000	0.000***	0.000**	0.000	0.000	0.000	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Male	0.187***	0.129***	0.179***	0.184***	0.179***	0.185***	0.186***
	(0.013)	(0.004)	(0.015)	(0.016)	(0.018)	(0.013)	(0.014)
Black	0.004	-0.021***	0.046	0.032	0.036	0.064	0.043
	(0.060)	(0.007)	(0.066)	(0.063)	(0.061)	(0.059)	(0.068)
Asian	0.048	0.129***	0.100***	0.104***	0.092***	0.078**	0.113***
	(0.032)	(0.019)	(0.035)	(0.040)	(0.035)	(0.037)	(0.041)
Hispanic	0.022	-0.028***	0.079	0.035	0.076	0.066	0.038
	(0.063)	(0.007)	(0.067)	(0.071)	(0.068)	(0.071)	(0.070)
Married	0.019	-0.004	0.027*	0.018	0.020	0.017	0.026*
	(0.014)	(0.006)	(0.016)	(0.017)	(0.017)	(0.015)	(0.016)
Master's Degree	0.014	-0.046***	0.028	0.027	0.007	0.029	0.041
	(0.027)	(0.006)	(0.030)	(0.023)	(0.021)	(0.029)	(0.028)
Ph.D. Degree	0.215***	0.162***	0.244***	0.294***	0.305***	0.229***	0.252***
	(0.033)	(0.011)	(0.044)	(0.031)	(0.037)	(0.036)	(0.036)
Professional Degree	-0.305***	-0.197***	-0.305***	-0.290***	-0.288***	-0.333***	-0.320***
	(0.025)	(0.003)	(0.028)	(0.029)	(0.029)	(0.024)	(0.028)
Visa F.E.	N	N	Y	Y	Y	Y	Y
Enrollment Year F.E.	Y	Y	Y	Y	Y	Y	Y
Country of Origin F.E.	N	Y	Y	Y	Y	Y	Y
Survey Year F.E.	Y	Y	Y	Y	Y	Y	Y
Country by Visa F.E.	Y	N	N	N	Y	Y	Y
Observations	22,668	146,354	17,994	16,904	13,795	19,145	21,103
R-squared	0.343	0.113	0.278	0.297	0.234	0.321	0.313
Pre-2008 D.V. mean for those arriving with student visas	0.4878	0.5082	0.4579	0.4535	0.3709	0.5042	0.5074

Notes: All specifications are based on the baseline model as in Table 2 Column 3. See notes underneath Table 1 for details on sample. In Specification (1) the control group includes individuals from Canada, Mexico, Chile, Australia, and Singapore, regardless of whether they first arrived with a student visa. Country by visa two-way fixed effects are included in this specification. Specification (2) uses the native-born as the control group. Specifications (3), (4), and (5) exclude Chinese individuals, Indian individuals, and both Chinese and Indian individuals, respectively. Specification (7) uses proxy enrollment dates given by: "BA=graduation year - 1" "MA=graduation year -1" "PhD=graduation year - 4" "Prof. Dgr=graduation year - 2". All regressions include a constant term. All estimates are calculated using sample weights. Standard errors are clustered on cells constructed based on whether the enrollment year was before vs. after 2008, visa status, and country of origin. *** p<0.01, ** p<0.05, * p<0.1

Table 4: Heterogeneous Impacts by Highest Educational Degree

Dependent Variable:	**STEM Major**		
Model Specification	**(1)**	**(2)**	**(3)**
	B.A.	**M.A.**	**Ph.D.**
Student Visa * Enroll 2008 or Later	0.038	**0.161*** **	**-0.197***
	(0.074)	**(0.059)**	**(0.113)**
Age	-0.014	-0.041**	-0.016
	(0.012)	(0.018)	(0.015)
Age Squared	0.000	0.000*	-0.000
	(0.000)	(0.000)	(0.000)
Male	0.257***	0.160***	0.115***
	(0.025)	(0.023)	(0.025)
Black	0.073	0.006	-0.049
	(0.080)	(0.064)	(0.147)
Asian	0.027	0.265***	-0.041
	(0.035)	(0.062)	(0.101)
Hispanic	0.034	-0.023	0.135
	(0.106)	(0.081)	(0.141)
Married	0.041*	0.007	-0.010
	(0.024)	(0.024)	(0.028)
Visa F.E.	Y	Y	Y
Enrollment Year F.E.	Y	Y	Y
Country of Origin F.E.	Y	Y	Y
Survey Year F.E.	Y	Y	Y
Observations	5,745	10,854	3,761
R-squared	0.321	0.316	0.345
Pre-2008 D.V. Mean for those arriving with student visas	0.3132	0.4890	0.7655

Notes: Analysis is performed separately for each highest degree completed. We do not show results for those with a professional degree because of the small number of observations. See notes underneath Table 1 for details on sample. Dependent variable: Highest degree being in a STEM field. All regressions include a constant term. All estimates are calculated using sample weights. Standard errors are clustered on cells constructed based on whether the enrollment year was before vs. after 2008, visa status, and country of origin. *** p<0.01, ** p<0.05, * p<0.1

Table 5: Tests for Differential Pre-trends

Dependent Variable:	**STEM Major**	
Model Specification	**(1)**	**(2)**
Sample	**All Degrees**	**Terminal Degree: Masters**
Panel A: Full Sample Period		
Student Visa * Enroll 2Yr Prior 2008	-0.104	-0.087
	(0.068)	(0.080)
Student Visa * Enroll 1Yr Prior 2008	0.020	-0.040
	(0.088)	(0.122)
Student Visa * Enroll 2008 or Later	**0.195*** **	**0.178** **
	(0.058)	**(0.086)**
Personal Characteristic Controls	Y	Y
Visa F.E.	Y	Y
Enrolment Year F.E.	Y	Y
Country of Origin F.E.	Y	Y
Survey Year F.E.	Y	Y
Observations	21,103	10,854
R-squared	0.314	0.314
Pre-2008 D.V. mean for those arriving with student visas	0.5084	0.4890
Panel B: Pre-2008 Sample Period		
Student Visa * Time Trend	0.004	-0.002
	(0.005)	(0.006)
Time Trend	Y	Y
Personal Characteristic Controls	Y	Y
Visa F.E.	Y	Y
Enrolment Year F.E.	Y	Y
Country of Origin F.E.	Y	Y
Survey Year F.E.	Y	Y
Observations	17,589	8,410
R-squared	0.304	0.303
Pre-2008 D.V. mean for those arriving with student visas	0.5084	0.4890

Notes: Dependent variable: Highest degree being in a STEM field. All regressions include a constant term. All regressions include a constant term. All estimates are calculated using sample weights. See notes underneath Table 1 for details on sample restrictions. Standard errors are clustered on cells constructed based on whether the enrollment year was before vs. after 2008, visa status, and country of origin. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 6: Heterogeneous Impacts by STEM Field

Dependent Variable	**Chosen STEM Major:**					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Model Specification	**Computer and Math Sciences**	**Life Sciences**	**Physical Sciences**	**Social Sciences**	**Engineering**	**Science and Engineering Related Fields**
Student Visa * Enroll 2008 or Later	0.015	0.027	-0.006	0.004	**0.053***	0.002
	(0.025)	(0.040)	(0.007)	(0.002)	**(0.031)**	(0.010)
Age	0.003	-0.018***	-0.003*	-0.000	-0.012	-0.002
	(0.006)	(0.006)	(0.002)	(0.000)	(0.007)	(0.002)
Age Squared	-0.000	0.000**	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Male	0.073***	-0.030***	-0.001	-0.002	0.141***	0.004
	(0.009)	(0.011)	(0.003)	(0.001)	(0.011)	(0.004)
Black	0.001	0.026	0.021*	-0.013	-0.013	0.018*
	(0.031)	(0.020)	(0.012)	(0.008)	(0.036)	(0.011)
Asian	0.043**	0.018	0.026	-0.006	0.022	0.009
	(0.021)	(0.016)	(0.018)	(0.008)	(0.022)	(0.010)
Hispanic	-0.007	0.054	0.013	-0.005	-0.008	-0.010
	(0.026)	(0.046)	(0.010)	(0.003)	(0.029)	(0.009)
Married	0.014	-0.002	0.006*	-0.001	0.015*	-0.006
	(0.009)	(0.007)	(0.004)	(0.001)	(0.008)	(0.006)
Master's Degree	0.007	-0.016	0.004	0.001	0.034**	0.012*
	(0.017)	(0.014)	(0.003)	(0.001)	(0.016)	(0.007)
Ph.D. Degree	-0.077***	0.147***	0.094***	0.008**	0.076***	0.000
	(0.025)	(0.018)	(0.010)	(0.003)	(0.025)	(0.006)
Prof. Degree	-0.121***	-0.068***	-0.013***	-0.000	-0.092***	-0.012***
	(0.012)	(0.012)	(0.003)	(0.001)	(0.015)	(0.004)
Visa F.E.	Y	Y	Y	Y	Y	Y
Enrolment Year F.E.	Y	Y	Y	Y	Y	Y
Country of Origin F.E.	Y	Y	Y	Y	Y	Y
Survey Year F.E.	Y	Y	Y	Y	Y	Y
Observations	21,103	21,103	21,103	21,103	21,103	21,103
R-squared	0.109	0.155	0.083	0.224	0.159	0.057
Pre-2008 D.V. mean for those arriving with student visas	0.1580	0.0827	0.0388	0.0016	0.2008	0.0265

Notes: Dependent variable: Highest degree being a particular STEM field (1= a particular STEM field, 0= any other STEM or non-STEM field). See notes underneath Table 1 for details on sample. All regressions include a constant term. All estimates are calculated using sample weights. Standard errors are clustered on cells constructed based on whether the enrollment year was before vs. after 2008, visa status, and country of origin. *** p<0.01, ** p<0.05, * p<0.1

Table 7: Heterogeneous Impacts by STEM Field for those with Master's Degrees

Dependent Variable	**Chosen STEM Major:**					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Model Specification	**Computer and Math Sciences**	**Life Sciences**	**Physical Sciences**	**Social Sciences**	**Engineering**	**Science and Engineering Related Fields**
Student Visa * Enroll 2008 or Later	0.032	**0.066***	-0.004	**0.003***	0.059	0.004
	(0.031)	**(0.036)**	(0.009)	**(0.002)**	(0.048)	(0.014)
Age	0.003	-0.010	-0.004*	-0.000	-0.026**	-0.005
	(0.010)	(0.008)	(0.002)	(0.000)	(0.012)	(0.003)
Age Squared	-0.000	0.000	0.000*	0.000	0.000*	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Male	0.076***	-0.043**	0.002	-0.001	0.132***	-0.006
	(0.015)	(0.018)	(0.003)	(0.001)	(0.013)	(0.005)
Black	-0.008	0.011	0.016*	-0.012	-0.040	0.038*
	(0.046)	(0.013)	(0.010)	(0.010)	(0.029)	(0.022)
Asian	0.141***	0.028	0.012	-0.022	0.073**	0.032
	(0.035)	(0.019)	(0.007)	(0.023)	(0.030)	(0.022)
Hispanic	0.027	-0.036	-0.000	-0.010	-0.012	0.008
	(0.049)	(0.023)	(0.007)	(0.008)	(0.033)	(0.014)
Married	0.003	0.003	0.005	-0.001	0.004	-0.006
	(0.016)	(0.009)	(0.004)	(0.001)	(0.014)	(0.011)
Visa F.E.	Y	Y	Y	Y	Y	Y
Enrolment Year F.E.	Y	Y	Y	Y	Y	Y
Country of Origin F.E.	Y	Y	Y	Y	Y	Y
Survey Year F.E.	Y	Y	Y	Y	Y	Y
Observations	10,854	10,854	10,854	10,854	10,854	10,854
R-squared	0.126	0.178	0.052	0.030	0.175	0.112
Pre-2008 D.V. mean for those arriving with student visas	0.2000	0.0322	0.0170	0.0000	0.2109	0.0288

Notes: Sample: Holders of master's degrees. See notes underneath Table 1 for more details on other sample restrictions. Dependent variable: Highest degree being a particular STEM field (1= a particular STEM field, 0= any other STEM or non-STEM field). All regressions include a constant term. All estimates are calculated using sample weights. Standard errors are clustered on cells constructed based on whether the enrollment year was before vs. after 2008, visa status, and country of origin. *** p<0.01, ** p<0.05, * p<0.1

Table 8: Impact of OPT-Extension on Marginal STEM Students

Dependent Variable	Non-STEM First Major to a Second Major, or Minor, in STEM		Non-STEM Lower Degree to a Higher Degree in STEM	
	(1)	(2)	(3)	(4)
Model Specification	**Double B.A.**	**Double M.A.**	**Non-STEM B.A. to STEM M.A.**	**Non-STEM M.A. to STEM Ph.D.**
Student Visa * Enroll 2008 or Later	-0.118	**0.113****	**0.111*****	-0.044
	(0.137)	**(0.057)**	**(0.033)**	(0.116)
Age	0.023	-0.002	0.019*	-0.045*
	(0.016)	(0.010)	(0.010)	(0.027)
Age Squared	-0.000	0.000	-0.000**	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Male	-0.006	0.011	-0.009	0.019
	(0.044)	(0.044)	(0.020)	(0.038)
Black	0.107	-0.030	0.065	0.004
	(0.168)	(0.060)	(0.041)	(0.081)
Asian	0.162	-0.043	0.015	0.102
	(0.194)	(0.063)	(0.055)	(0.108)
Hispanic	0.022	-0.083	-0.095*	0.030
	(0.151)	(0.075)	(0.052)	(0.089)
Married	0.004	-0.019	-0.036	0.045
	(0.032)	(0.033)	(0.025)	(0.034)
Enrollment Year F.E.	Y	Y	Y	Y
Visa F.E.	Y	Y	Y	Y
Country of Origin F.E.	Y	Y	Y	Y
Survey Year F.E.	Y	Y	Y	Y
Observations	423	599	2,480	790
R-squared	0.687	0.412	0.246	0.418
Pre-2008 D.V. mean for those arriving with student visas	0.0328	0.0657	0.0988	0.1653

Notes: Dependent variables for Specifications (1) to (2): 1 = non-stem first major to stem second major; 0 = non-stem first major to non-stem second major. Dependent variables for Specifications (3) to (4): 1 = non-stem lower to stem higher degree; 0 = non-stem lower to non-stem higher degree. See notes underneath Table 1 for further details on sample restrictions. All regressions include a constant term. All estimates are calculated using sample weights. Standard errors are clustered on cells constructed based on whether the enrollment year was before vs. after 2008, visa status, and country of origin. *** p<0.01, ** p<0.05, * p<0.1