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# International Student Enrollments and Selectivity: Evidence from the Optional Practical Training Program

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# ABSTRACT

## International Student Enrollments and Selectivity: Evidence from the Optional Practical Training Program

We examine how the 17 month extension of Optional Practical Training—a program that allows international Science, Technology, Engineering and Math (STEM) majors the opportunity to work in the United States for 1-2 years following graduation—affects the quantity and quality of international students. Extension benefits not only include extended work duration, but also an additional attempt at securing more permanent employment through an H-1B visa. We find sizable positive treatment effects on the number of students matriculating into U.S. higher education, and also increases in the quality of students, as captured by the selectivity of institutions they attend.

**JEL Classification:** F22, J61, J68

**Keywords:** optional practical training, international students, enrollments, selectivity, United States

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## I. Introduction

The number of international students exceeded 1 million in 2018 for the third year in a row, even though new enrollments dropped by 6.6 percent in 2017/18 continuing a downward trend first observed in 2015/2016 (Open Doors Report, IEE 2018). The gains in overall students are primarily due to the increase in students participating in the Optional Practical Training (OPT) program, which allows international students to practice their skills by working in the United States for up to 12 months during or after their academic programs (Brier 2020). Since 2014, the number of international students working in the United States through OPT has consistently exceeded the number of H-1B visas issued (Ruiz and Budiman, 2018)–the nation's largest temporary employment visa program. Unlike H-1B visas, there is no cap on the number of OPT approvals; plus, employer sponsorship is not required. Given the shortage of H-1B visas, international students appear to have increasingly turned to OPT to acquire U.S. work experience. In addition to the extended work experience and U.S. wages,[1] the OPT extension effectively provides international graduates an additional chance to enter the H-1B lottery.

In this paper, we address how OPT policy impacts international student entry into U.S. higher education, with a focus on both scale and selection. Despite the tremendous growth of OPT in recent years, little is known about its implications for international students in higher education and their work placements. We examine three OPT policy interventions that likely altered the returns to studying in the United States for STEM majors.[2] In 2008, the duration of work authorization was expanded from 12 to 29 months for international students graduating in STEM

[1] There are other financial considerations/benefits to both prospective employers and international students in OPT. For instance, employers do not pay a complete compensation package to OPT workers, who are still considered international students, and OPT workers do not pay social security and Medicare taxes given their nonresident status.

[2] The OPT program for STEM fields was further extended to 36 months by a reform on May 10, 2016. Given the data availability of this study, we focus on the 2008, 2011, and 2012 reforms.

fields. In 2011 and 2012, the list of fields eligible for the 29-month extension was lengthened, and more majors (*e.g.* econometrics) qualified as STEM. Using a difference-in-differences design, we compare how the quantity and type of international STEM students changed with the OPT extension and expansion reforms, relative to non-STEM students and, in alternative model specifications, native students.

Prior studies have pointed out the responsiveness of international enrollments to changes in immigration policy and U.S. labor market prospects (*e.g.* Kato and Sparber 2013, Bound *et al*. 2014, Shih 2016, Chen *et al*. 2020). In addition, recent work by Demirci (2019) demonstrates how the number of international students staying in the United States after graduation increased after the 2008 OPT extension, and how it may have negatively impacted native workers. Yet, to date, it remains unclear how the three (2008, 2011, and 2012) OPT reforms impacted U.S. higher education in terms of the scale and selectivity of international enrollments, which are crucial in determining labor market impacts.

To address this gap, we draw upon various sources of data, including administrative data from the U.S. government obtained through a Freedom of Information Act (FOIA) request, data from the National Survey of College Graduates (NSCG) and institutional data from Integrated Postsecondary Education Data System (IPEDS). The administrative data contains information on the degree pursued (type of degree and field), institution attended, grants and other support received and the amount spent on their education for all international students –those in STEM, as well as those in non-STEM fields. The NSCG contains similar information for both native and international students, allowing us to gauge the policy impacts, using native students as a comparison group. Finally, we use IPEDS data to merge other information on institutional traits that shed further light on the educational implications that the policies have had on international students' educational decision-making and the quality of institutions attended.

Overall, our findings reveal that the OPT extension and expansion had sizable impacts on the number and type of students matriculating in U.S. higher education. Our preferred treatment effect estimates indicate that international enrollment in STEM fields grew by 17 percent among students pursuing a Bachelor's degree, and by 30 percent among Master's students in response to the changes in the OPT program. The fact that the impact was concentrated in these two programs is not surprising. After all, one of the main benefits of the OPT extension is the ability to enter more than once the H-1B visa lottery. Yet, Associate's and Doctoral level programs either do not qualify for an H-1B or have the option of employment in the academic sector, which is exempt from the H-1B visa cap (Amuedo-Dorantes and Furtado, 2018). Importantly, when distinguishing across the three OPT reforms, we find that all of them had similar impacts, even though the impact of extending the duration of OPT (2008 OPT reform) was somewhat smaller than the effect of expanding the list of eligible majors (2011 and 2012 OPT reforms). The fact that all three reforms affected enrollments similarly is suggestive of the found impacts not being a byproduct of potentially confounding factors, such as the 2008 Great Recession.

To conclude, we also examine the impact of the OPT reforms on the selectivity of international students. We find evidence of OPT reforms raising the number of students attending top universities, as captured by their classification as research or Master universities, their low admissions rates, high expenditures per student, and student financial support in the form of scholarships and fellowships.

The paper is organized as follows. Section II describes the institutional background and policy changes to OPT. Section III provides a theoretical framework to guide the empirical analysis. Specifically, a random utility model is used to derive some predictions regarding scale and selection impacts. Section IV discusses the methodology, and Section V describes the data. Section VI contains a discussion of our findings, including several robustness checks, and Section VII concludes the study.

## II. Institutional Background

Optional Practical Training (OPT) allows international students on an F-1 visa to gain work experience. The program was only designed for temporary work as a form of training, allowing students to work for one year, after which they would need to either leave the country or switch to a different form of legal status. This work experience may be gained either prior to the degree completion, in which case it counts towards the overall OPT duration allowed for by law, or after completion of the degree –the most popular option, with students being able to apply up to 90 days prior to graduation until 60 days after graduation.

Up until 2008, the OPT period was limited to 12 months. However, in 2008, in response to increased lobbying by industry and high-tech companies, OPT was extended by 17 months, allowing for a total of 29 months for graduates from science, technology, engineering and mathematics (STEM) fields. In 2011 and 2012, there were two additional reforms that extended the list of eligible majors for the OPT extension. For instance, all majors with 6-digit CIP codes ending in “99” (also known as “catch-all” majors) became eligible for the OPT extension in 2012.[3] In addition, there were other majors that gained eligibility, including some in environmental studies (*e.g.* Urban Forestry) and quantitative intensive economics (*e.g.* Econometrics).

[3] An example of a “catch-all” CIP code ending in “99” would be a specialized type of biology major that does not fit into any of the already well-defined 6-digit CIP codes for Biology.

The intention of these reforms was to retain talent amidst concerns about the loss of U.S. trained talent in STEM fields due to students' inability to secure an H-1B visa. Amuedo-Dorantes, Furtado and Xu (2019) document how the 2008 OPT reform might have helped steer more students towards STEM fields, and Demirci (2019) documents how the 2008 reform rose retention. However, we still do not know much how the policy might have impacted international students' educational enrollments and selectivity. The ability to extend the duration of their training may have encouraged more students to study in the United States, as well as altered the selection of students in a number of dimensions, as captured by the type of institution they attend and its traits (*i.e.* public, private, research oriented, lower admission rates, greater expenditures per student, or larger institutional support offered to students).

In addition, we do not know if the impact of more recent OPT reforms has differed from the one in 2008. In 2011 and 2012, the Department of Homeland Security (DHS) expanded the list of STEM designated degree programs that would qualify for the extended OPT with the purpose of embracing and retaining talented students from other countries. The new programs included fields as pharmaceutical sciences, econometrics and quantitative economics.[4] While simple descriptive statistics suggest that the above-mentioned policies have contributed to the increase in international students choosing STEM fields (Ruiz and Budiman, 2018), especially for post-baccalaureate degrees, we still do not know how the latest reforms have impacted enrollments in STEM fields by type of degree, nor how they may have altered student selectivity. Our aim is to address this gap in the literature to enhance our understanding regarding the effectiveness of the

[4] A full list of expanded STEM degrees is available at https://www.dhs.gov/news/2012/05/11/dhs-announces-expanded-list-stem-degree-programs.

various policy approaches in achieving their goal, as well as on their implications on the overall volume and quality of U.S. international student enrollment.

## III. Conceptual Framework

The literature has documented the various motives driving international students' pursuit of an academic degree in the United States. Some studies emphasize the desire for students to pursue educational opportunities that are simply not available in their home countries or are hard to reach for a number of reasons, such as competition (Rosenzweig, 2006; Hwang, 2009; Bird and Turner, 2014). Others underscore students' desire to live and work in the United States after completion of their academic degrees as the main motive driving their choice to study in the United States (Kato and Sparber, 2013; Bound *et al*., 2014). Finally, students may also come for other motives, such as family reunification, which might drive international students to come and complete their education, possibly staying in the United States thereafter.

We utilize a random utility model to highlight the benefits of OPT and derive some predictions on the scale and selection effects of the OPT reforms. We assume individuals in a foreign country decide on a major (STEM or non-STEM) and destination of study (United States or Home), by comparing the expected return associated with each choice, which is a function of potential earnings and costs. Log wages for STEM and non-STEM graduates are given by:

$$w_{imj}^{d} = \overline{w^{d}} + (r_{m}^{d} + \sigma_{mj})D_{im}^{d} \qquad (1)$$

All workers earn, at a minimum, the average wage in country $d$, given by $\overline{w^{d}}$. In addition, post-secondary education confers the country-major specific return: $r_{m}^{d}$. The indicator variable, $D_{im}^{d}$, equals 1 if individual $i$ graduates with major $m$ from country $d$. Finally, we allow for individuals to earn an additional premium determined by their major-specific ability, $\sigma_{mj}$, which we assume to be invariant across countries.[5] The ability premium is increasing in $j$, such that $\sigma_{mK} > \sigma_{mk}$ for all $K > k$. Individuals pay the cost: $c^d$, which varies only across destinations, as tuition is generally set at the university-level and varies across destinations. The cost also includes migration costs for those studying in the United States.

The utility derived from studying in the United States or at home is linear in parameters and depends on both wages and costs. Furthermore, we allow for uncertainty in employment to vary across countries by defining: $p_m^d$ –namely, the probability that an international student with major $m$ works in country $d$. Since studying in the United States does not guarantee being able to work and earn U.S. wages, we define the probability of working in the U.S. as: $0 < p_m^{US} < 1$. Individuals return home after graduation if they cannot work in the U.S. with probability $(1 - p_m^{US})$. Furthermore, employment probabilities may differ by major, due to changing demand for skills, and with the current immigration policy, *e.g.* OPT. For simplicity, we assume studying at home allows you to work and earn home country wages with certainty; that is: $p_m^H = 1$. Similarly, we segment labor markets entirely, so that individuals with a non-STEM degree cannot work in STEM occupation, and vice-versa. With $\gamma$ as the marginal utility of income, the expected utilities from pursuing study in the United States and at home are given by equations (2) and (3), respectively:

(2) $$u_{imj}^{US} = \gamma\left(\left[p_m^{US} w_{imj}^{US} + (1 - p_m^{US}) w_{imj}^{H}\right] - c^{US}\right) + \varepsilon_{imj}^{US}$$

(3) $$u_{imj}^{H} = \gamma\left(w_{imj}^{H} - c^{H}\right) + \varepsilon_{imj}^{H}$$

[5] For simplicity, we assume that major-specific ability has the same return to earnings in both countries. However, in practice, it may be the case that, despite both being correlated, major-specific ability does not yield the same return across countries.

If $\varepsilon_{im}^{d}$ is an i.i.d. error term with a type-I extreme value distribution, and we define $V$ to represent observed utility (*i.e.* $u - \varepsilon$), then the probability of studying major $m$ in the United States and at Home can be written as (McFadden, 1974):

(4)
$$P_{imj}^{US} = \frac{\exp\left(V_{imj}^{US}\right)}{\Sigma_d \Sigma_m \exp\left(V_{imj}^{d}\right)} \text{ and } P_{imj}^{H} = \frac{\exp\left(V_{imj}^{H}\right)}{\Sigma_d \Sigma_m \exp\left(V_{imj}^{d}\right)}$$

Focusing on the choice to study STEM in the United States, we can take logs on both sides of equation (4), yielding an expression that linearly relates the enrollment probability in U.S. STEM majors (*i.e.* $m = S$) to expected wages and costs:

(5a)
$$logP_{iSj}^{US} = \gamma\left(p_S^{US} w_{Sj}^{US} + (1 - p_S^{US}) w_{Sj}^{H}\right) - \gamma c^{US} - \log\left(\Sigma_d \Sigma_m \, exp\left(V_{imj}^{d}\right)\right)$$

(5b)
$$log\,\frac{E_{Sj}^{US}}{Pop^{H}} = \gamma\left(p_S^{US} w_{Sj}^{US} + (1 - p_S^{US}) w_{Sj}^{H}\right) - \gamma c^{US} - \log\left(\Sigma_d \Sigma_m \, exp\left(V_{imj}^{d}\right)\right)$$

Intuitively, equation (5a) reveals the likelihood of studying in the United States is increasing in U.S. wages ($w^{US}$) and the likelihood of finding employment in the U.S. ($p^{US}$), and decreasing in home wages ($w^{H}$) and costs of studying in the U.S. ($c^{US}$). Additionally, enrollment is decreasing in the value of alternative options, which are captured by the term last term, $\log\left(\Sigma_d \Sigma_m \, exp\left(V_{imj}^{d}\right)\right)$.

To inform our empirical strategy, we transform probabilities into their empirical analogue, population shares in equation (5b). Specifically, the likelihood of studying in the United States for an intending STEM major $\left(P_{iSj}^{US}\right)$ can be approximated by the fraction of the home country's student population studying STEM in the US $\left(\frac{E_{Sj}^{US}}{Pop^{H}}\right)$.

Given the relationship in equation (5b), we now derive some predictions regarding the impact of the OPT reforms on enrollments. OPT reforms increased the probability of being able to work in the United States for STEM majors, assuming wages and costs remain unchanged.[6] The reforms extended the work duration by 17 months, and also the number of majors eligible for this extension. In addition, they conferred students an additional chance to secure an H-1B work visa–the main path of entry into the U.S. labor market for international students who received their college degrees in the United States. However, the H-1B visa program has been tightly capped at 85,000 visas per year, and this cap has been exhausted every year since 2004 (Mayda *et al*. 2018). In response to overwhelming demand for H-1B visas, lotteries have been held to determine their recipients in 2007, 2008 and from 2014 onward (Mayda *et al*. 2020). Prior to 2008, STEM students only had 12-months of optional practical training, providing them with one chance to secure an H-1B visa. The 17-month extension effectively doubled their chances by allowing them to enter the visa lottery twice. As such, the reform raised applicants' odds of migrating and working legally in the United States on a more permanent basis. Hence, OPT reforms can be viewed as increasing the likelihood of working in the United States.

If we differentiate equation (5b) with respect to the probability of working in the United States ($\mathrm{p}_S^{US}$), and simplify, we obtain:

(6a)
$$\frac{dlog\,\frac{E_{Sj}^{US}}{Pop^H}}{d\mathrm{p}_S^{US}} = \left(w_{Sj}^{US} - w_{Sj}^{H}\right) - \frac{\exp\left(V_{iSj}^{US}\right)}{\Sigma_d \Sigma_m\, exp\left(V_{imj}^{d}\right)}\left(w_{Sj}^{US} - w_{Sj}^{H}\right)$$

(6b)
$$\Delta log\,\frac{E_{Sj}^{US}}{Pop^H} = \left(w_{Sj}^{US} - w_{Sj}^{H}\right)\left(1 - P_{iSj}^{US}\right)\Delta \mathrm{p}_S^{US}$$

(6c)
$$logE_{Sj}^{US,post} - logE_{Sj}^{US,pre} = \left(w_{Sj}^{US} - w_{Sj}^{H}\right)\left(1 - P_{iSj}^{US}\right)\left(\mathrm{p}_S^{USpost} - \mathrm{p}_S^{USpre}\right)$$

[6] For simplicity, we assume no general equilibrium impacts on wages. However, prior research has found that natives' wages and employment opportunities might have been negatively affected by the 2008 OPT extension (Demirci, 2019).

Equation (6b) follows from substituting $P_{iSj}^{US} = \frac{\exp\left(V_{iSj}^{US}\right)}{\Sigma_d \Sigma_m \, exp\left(V_{imj}^{d}\right)}$, that is the fraction of home country students studying STEM in the United States, and also by mapping to our empirical analysis, using the fact that changes ($\Delta$) provide the discrete analogue to differentials. Equation (6c) follows by further mapping to a difference-in-difference framework, considering change post- and pre-reform, and assuming the home country student population is large enough to not change substantially. The resulting equation (6c) reveals that the increase in log enrollment of international STEM students depends on the extent to which OPT alters the probabilities of working in the United States. This is scaled by the size of the wage gap between the United States and the home country, such that large changes in the probability of working in the United States, due to OPT reforms, are further magnified if wage gaps (*i.e.* returns to working in the United States) are large. This is further weighted by the initial fraction of home country student population studying in the United States. Intuitively, the increase will be proportionally larger if there are few home country students studying in the United States prior to reform, and alternatively, the reform have no impact if all of the home country students are already studying in the United States (*i.e.* $P_{iSJ}^{US} = 1$). We anticipate estimated treatment effects to be positive, given that U.S. average wages exceed those in many of the top sending countries (*e.g.* China and India), and the share of students already studying in the United States is well below 1 for many of the large sending countries (*e.g.* China and India).

We can also use this framework to gather some insights into the impact of OPT reforms on the selectivity of international STEM students. Specifically, we examine equation (6c) and compare them for students of two different ability levels, $a$ and *b*, where *a*> *b*, as follows:

$$(7) \qquad log\frac{E_{Sa}^{US,post}}{E_{Sb}^{US,post}} - log\frac{E_{Sa}^{US,pre}}{E_{Sb}^{US,pre}} = [(w_{Sa}^{US} - w_{Sa}^{H})(1 - P_{iSa}^{US}) - (w_{Sb}^{US} - w_{Sb}^{H})(1 - P_{iSb}^{US})](\mathrm{p}_S^{USpost} - \mathrm{p}_S^{USpre})$$

Equation (7) reveals that the relative log enrollment of high ability ($a$) and low ability ($b$) students depends on the difference in relative returns to ability in the United States versus the home country, scaled by the initial fractions of home country students of each ability type in the United States. While the probability of working in the United States is constant across ability types, this might be a reasonable assumption given that during most of the post-OPT reform period, the H-1B visas that were capped were distributed by random lottery. For illustrative purposes, suppose the baseline probabilities of studying STEM in the United States are identical for students of abilities $a$ and $b$, such that $P_{isa}^{US} = P_{isb}^{US}$. Intuitively, then, positive selection occurs if, $w_{sa}^{US} - w_{sa}^{H} > w_{sb}^{US} - w_{sb}^{H}$; in other words, if the returns to studying in the United States are larger for students of higher ability (which is guaranteed by equation 1). Negative selection can occur if the initial fraction of high ability ($a$) students in the United States is very large relative to lower ability ($b$) students, *i.e.* $P_{iSa}^{US} > P_{iSb}^{US}$—intuitively if all of the high ability home country students are already in the United States, then they won't respond to OPT reforms, so that the response only comes from low ability students.

For simplicity, we only model the supply side of international student decisions. However, it is important to recognize that treatment effects will also be moderated by demand side conditions (*e.g.* Mayda, 2010). In particular, existing admissions policies at universities that govern international enrollment can play an important role – even if we assume they do not endogenously change in response to OPT reforms. For example, consider a university that already has met their quota for international students' admittance prior to the OPT reform. Because of the binding quota, they cannot accept any further international students. Thus, the OPT reforms will not increase international enrollment.

In addition to providing some testable hypotheses, this model is useful in guiding our empirical approach. Equations (6c) and (7) motivate a difference-in-differences approach, examining changes in log enrollment before and after OPT reforms. In the next section, we describe our difference-in-differences approach in greater detail.

## IV. Empirical Methodology

We rely on a difference-in-differences approach to estimate the effects of the OPT reform on international student enrollments. Since eligibility for the OPT extension depends on the type of major pursued and year in question, we track student cohorts by major (*m*) and matriculation year (*t*). In addition, we distinguish by gender (*g*) given the distinct incidence of STEM fields among men and women. To that end, we begin by estimating the following benchmark model specification:

$$\log(E_{gmt}) = \alpha + \beta_1(treat_{mt}) + \gamma_{gm} + \gamma_{gt} + \varepsilon_{gmt} \quad (8)$$

where the dependent variable, $E$, is the number of international students of gender $g$, in major $m$, starting a U.S. degree in year $t$. To account for the zero cells in the log number of students per gender-major-year cell, the dependent variable is transformed using an inverse hyperbolic sine function.[7] The treatment indicator, $treat_{mt}$, takes a value of 1 when major *m* becomes eligible for the extended OPT following the reform in year *t* (*i.e.* 2008, 2011, or 2012), and 0 otherwise.

[7] The inverse hyperbolic sine transformation is given as: $\sinh^{-1} E = \log(E + \sqrt{E^2 + 1})$. Gelber (2011) uses the inverse hyperbolic sine transformation and provides more details about its properties in relation to logs. All the analyses use balanced gender-major-year cells over time, unless otherwise stated. As a robustness check, we also estimate our models taking the natural log of enrollments, which drops non-zero cells. Results, available upon request, remain robust even though over half of the major-gender cells are dropped due to zeros.

Equation (8) includes major-by-gender fixed effects ($\gamma_{gm}$) and cohort-by-gender indicators ($\gamma_{gt}$) to account for time-invariant differences across major-gender pairs. Cohort-by-gender indicators control for aggregate shocks/trends that may differ by gender. We also cluster standard errors at the major-gender level. As such, the coefficient $\beta_1$ provides a difference-in-difference estimate of how OPT reforms impacted STEM enrollments from abroad.

When examining selection effects, the dependent variable in equation (8) restricts the sample to particular types of students (*e.g.* those with high amounts of funding, students enrolling in selective universities with low admissions rates, students enrolling in universities with more funds per student, students receiving more university funding), maintaining the comparison between eligible to ineligible groups.

Causal inference in a difference-in-differences framework relies on student enrollment in the control group representing an appropriate counterfactual for student enrollment in eligible majors in the absence of OPT extensions. We examine the suitability of different control groups among the ineligible international student population. In addition to using the most obvious control group composed of all ineligible, non-STEM international students,[8] we experiment with using Business majors as a counterfactual group for several reasons. As we show in the following section, at baseline, Business students appear more similar to STEM majors than students in non-STEM majors. In addition, enrollment trends in Business majors closely track enrollments trends in STEM majors in the pre-reform period – a necessary assumption for valid difference-in-difference estimation, which we show is violated when using all non-STEM or non-Business enrollments. At the same time, however, STEM fields may be closer substitutes for Business

[8] In column (1) of Table 4, we display our main findings when using all non-STEM students as a control group. As can be seen there, results prove robust to the use of this simpler, comprehensive control group.

majors than other non-STEM major, such as Art for example. In that case, treatment effects when using Business as a counterfactual may be biased upwards, as OPT reforms induce potential STEM majors to instead switch and declare Business upon matriculation. Therefore, we provide a range of results using various control groups, including all international non-STEM majors, international non-Business majors, international Business majors, native-born STEM students, and finally, a synthetic control group.

Another important concern in our setting is the timing of the OPT reforms; in particular, the first OPT reform in 2008 coincided with the Great Recession. Treatment effects for that reform may be confounded by the impact of the downturn on international student enrollments and differential impacts on STEM and non-STEM fields. While including year dummies should help absorb aggregate fluctuations, we perform additional checks to help account for variation across majors. First, we consider the broad scope of the 2008 Great Recession. If the impacts attributed to the 2008 OPT reform were solely the byproduct of the economic downturn, we should expect similar trends for Associate and Doctoral degree holders–groups that should be much less responsive, or even non-responsive, to the OPT extensions due to program stipulations and other work visa pathways.[9] In separate analyses, we show that international STEM enrollment in Associate's and Doctoral programs did not see large impacts after 2008, even though we observe impacts for students pursuing Bachelor's or Master's degrees. This helps support the notion that estimated impacts do not entirely measure recessionary effects.

[9] As noted earlier, one of the main benefits from the OPT extension is the possibility to double the chances of getting an H-1B visa by participating in the lottery more than once. Since Associate degree holders do not qualify for an H-1B and many doctoral degree holders are able to find employment in the academic sector, which is exempt from the H-1B visa cap (Amuedo-Dorantes and Furtado, 2018), the OPT extension should have a zero to negligible impact on their enrollments and selectivity.

Secondly, if the observed impacts of the 2008 OPT reform primarily reflect the impact of the 2008 Great Recession, we should expect distinct results from the 2011 and the 2012 OPT reforms as they occurred outside of the height of recessionary pressure. To that end, we provide some empirical evidence using a similar differences-in-differences approach that separately examines the three reforms. We modify equation (8) to add interactions of the post-policy indicator with the $OPT_m$ dummy. The interaction terms take the value of 1 for majors that started to become eligible under the specified reform. Our new model specification is given by:

$$(9) \qquad \log\left(E_{gmt}\right) = \alpha + \beta_1(OPT_m \times Post08) + \beta_2(OPT_{m'} \times Post11) + $$

$$+ \beta_3(OPT_{m''} \times Post12) + \gamma_{mg} + \gamma_{gt} + \varepsilon_{gmt},$$

where the coefficients $\beta_1$, $\beta_2$, and $\beta_3$ capture the impact of the three reforms, respectively.

Finally, we conduct additional checks to assuage concerns about the Great Recession and other endogeneity. For instance, we calculate major-specific unemployment rates using major-to-occupation crosswalks and include them as an additional control. We also experiment with using native-born STEM majors as an alternative control to eliminate the influence of differential impacts of the Great Recession on STEM vs. non-STEM majors. Lastly, we estimate specifications that account for major-specific linear trends.

## V. Data

We obtain data on international student enrollments from a variety of sources. We obtain data from the Student Exchange and Visitors Information Service (SEVIS) on all international students entering U.S. higher education institutions from 2004-2016 through a freedom of information act request. Each record contains both demographic, educational, and funding information. The demographic variables include the country of origin, gender, and birth date of each student. The educational information includes the institution, level of study, start and end dates, and major field of study disaggregated at the 6-digit CIP code level.[10] Finally, funding information includes self-reported amounts of tuition and expenses students anticipate paying, and the source and amount of funds they have at their disposal. Using SEVIS data, we create gender-major-year cells for the analysis of international students.

To obtain information on native-born student enrollments, we use the National Survey of College Graduates (NSCG). The NSCG is a biennial survey of college graduates conducted by the Census Bureau and sponsored by the National Science Foundation. We use the 2010, 2013, 2015, and 2017 waves of the NSCG data and keep students who were likely to have started their studies between 2004 and 2012 to match the data on international students from SEVIS.[11] The NSCG contains information on 7 broad fields of study and about 142 specific majors, which we crosswalk to the 6-digit CIP code classification and categorize into STEM-eligible and non-eligible majors according to the 2008, 2011 and 2012 OPT policies.

To obtain information on institutional traits, we merge data from the Integrated Postsecondary Educational Data System (IPEDS), which is maintained by the Department of Education. Specifically, we classify institution type by control status (public, private-for-profit, private-not-for-profit) and Carnegie Classification (research-oriented universities, Master's programs universities, Baccalaureate programs universities).[12] We also rank institutions by their admissions rate and the total funds they receive per student.[13]

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[10] CIP codes refer to the Classification of Instructional Programs used by the Department of Education to categorize major fields of study. The 6-digit CIP code is the most disaggregated-level for majors.

[11] NSCG only contains information on one's graduation year, thus, we proxy for the date a student began the study. We set the start year to four years prior the graduation year if a student's terminal degree is a bachelor's, five years prior the graduation year for Ph.D. students, and two years prior to graduation year for masters and professional degree holders. We stop in 2012, as reliable counts of students beyond 2012 diminish in number as students have not completed their degrees yet.

[12] This definition follows the 2005 Basic Carnegie Classification.

[13] Average admission rate is calculated by author using IPEDS information from 2004/05 academic year to 2007/08 academic year. Total funds per student is based on the 2004 Fiscal Year information from IPEDS.

We provide some descriptive statistics of international students in the SEVIS dataset in Table 1. The table shows mean characteristics of students at baseline (prior to 2008), separately for STEM majors eligible for the 2008, 2011, and 2012 extensions (*i.e.* "STEM" in column (1)), and our preferred control group of Business majors, in column (2). A few differences are noteworthy. First, 58 percent of students in Business majors are male, compared to 71 percent of the students in STEM majors, consistent with the notion that many STEM fields are male dominated. Additionally, students in STEM majors are far more likely to be from China or India, the top two senders of international students to the United States.

There are also differences across fields of study. Students in STEM majors are less represented in undergraduate programs, and more highly represented in Doctoral programs than Business majors. This is also reflected in a slightly longer average duration of schooling, with STEM majors enrolled for 3 years versus 2 for Business majors.

In terms of student quality, STEM and Business students appear equally likely to enroll in highly selective institution as captured by those whose admissions rate ranks in the 1$^{st}$ quartile. STEM and Business majors are also similar in terms of their average monthly expenses (including tuition and living expenses) and personal monthly funds. Finally, STEM students have a higher likelihood of using the OPT program—67% of STEM students end up using OPT versus 47% for Business majors. This may be due to the OPT reforms, or differing labor market opportunities by field.

Importantly, Business majors are much closer to STEM students in terms of mean characteristics than other non-STEM majors, shown in column (4). When compared with our treatment group, other non-STEM majors are less likely to be male, more likely to be older, far less likely to come from China and India, and less likely to use the OPT program. Business students are also close to STEM students in terms of the type of institutions they attend and the amount of monthly expenses they spend. This evidence is one feature of the data that lead us to prefer using Business majors as a control group. Nonetheless, we provide checks when including these other non-STEM majors.

***Descriptive Evidence of the Validity of the Quasi-Experimental Design***

Figure 2 shows trends in average international student matriculation in STEM (eligible) and non-STEM (ineligible) 6-digit CIP code majors over time. Trends in international student enrollments in Bachelor's degree programs (Figure 2a) moved in a parallel fashion for STEM and non-STEM majors prior to the first OPT reform in 2008. The trends start to diverge in 2010, with STEM majors outpacing non-STEM. Enrollments in Master's degrees in STEM majors (Figure 2b) also outpaced enrollments in non-STEM majors; however, the divergence began earlier, around 2006, and sharply widened after 2012. These trends provide suggestive evidence of the role that the OPT reforms might have played in encouraging STEM enrollment from abroad. Alternatively, they may capture other factors, such as the role of the Great Recession, or, in the case of Master's degree enrollment, potential pre-existing differential trends.

We also examine the evolution of international matriculation in Associate's and Doctoral programs, which should have been less affected by the OPT reforms. As noted earlier, an important benefit of the OPT extension is the ability to participate multiple times in the H-1B lottery. However, Associate degree holders do not qualify for an H-1B visa. Similarly, Doctoral degree holders are not as reliant on the H-1B lottery, as many find employment at Universities and research institutes exempt from H-1B limits (Amuedo-Dorantes and Furtado, 2018). Figure 2c shows that international enrollment in STEM and non-STEM majors moves in similar fashion throughout the time period for Associate's degree programs, with little suggestive evidence of a rise in STEM majors in response to the OPT reform. For Doctoral programs (Figure 2d), STEM enrollment moves in a pattern that appears countercyclical to the Great Recession, while non-STEM enrollments remain very low and flat. Hence, descriptive trends are less supportive of an effect of OPT reforms on enrollments in Doctorate degree programs.

Because these descriptive trends are only suggestive, in what follows, we more formally assess the effect of the OPT extensions on international student enrollments and selectivity. We focus on students in Bachelor's and Master's programs, who are more likely to respond to changes in the OPT program. Our analysis confirms that Associate's and Doctoral degree programs were largely unaffected by the OPT reforms, and also uses these groups to run placebo checks to assess the role of potential confounders impacting our estimates during the period under examination.

## VI. OPT Extension Impacts on International Student Enrollments and Selectivity

### A) Enrollment Impacts

To learn about the impacts of the various OPT reforms on international student enrollments in STEM, we start by estimating equation (8) using data on STEM and Business majors (our primary control group) from SEVIS. As discussed earlier, Figure 2a and 2b show that there were significant increases in international student enrollments in Bachelor's and Master's degrees around the period following one or more of the OPT reforms. Table 2 shows the results from estimating equation (8). International student enrollments in Bachelor's degrees in STEM (Panel A of Table 2) rose by 17 percent following OPT reforms, with somewhat greater increases among men (21 percent) when compared to women (13 percent). The growth was also remarkable in Master's programs, where international student enrollments in STEM grew by 30 percent – 33 percent among men and 28 percent among women. In what follows, we assess the degree to which these impacts can be interpreted as causal or, instead, are confounding the impact of other factors.

*Identification and Robustness Checks*

An immediate concern with the difference-in-difference estimates in Table 2 refers to the possibility of pre-existing differential trends in international student enrollments in STEM relative to non-STEM fields driving the results. To gauge if this is a valid concern, we conduct an event study analysis for international matriculation in Bachelor's and Master's programs by estimating the following model:

$$\log(E_{gmt}) = \alpha + \sum_{i=-4}^{4} \phi_i 1(T_{mt} = i) + \gamma_{mg} + \gamma_{gt} + \gamma_m \times t + \varepsilon_{gmt}, \quad (10)$$

where $T_{mt}$ denotes the event year. We include up to 4 years prior and post each OPT reform. Note that $T = 0$ for enrollments taking place during the year that major $m$ is affected by the OPT extension, $T = 1$ for enrollments occurring one year after the OPT extension affecting major $m$, and so on. The event study analysis requires for enrollments to be centered on an event time; therefore, only STEM majors affected by a reform are included. Coefficients are measured relative to one year prior to the OPT reform impacting the major in question, *i.e.* $T =$-1. We include major-gender fixed effects, gender-cohort fixed effects, and major-specific linear time trends.

Figure 3 plots the estimated coefficients $\phi_i$ from estimating equation (10), along with the corresponding 95% confidence intervals. There seems to be some evidence of a break in the trend in international student enrollments in Bachelor's degrees in response to the OPT reform, with little evidence of a differential trend prior to reform. However, the case is less clear for international student enrollments in Master's degrees. While enrollments increase following OPT reforms, it is difficult to distinguish this rise from a pre-existing trend. This may be due to the fact that some Master's students may be working towards Doctoral programs, earning a Master's degrees in-route. If that were the case, their fluctuations might resemble those in Doctoral degree programs, which appear to move countercyclically with the Great Recession. Alternatively, enrollment in Master's degree programs, because of their shorter duration, might be particularly responsive to changing labor market conditions and a growing demand for workers with expertise in STEM fields. This might be especially true if they are able to significantly improve their employment opportunities by completing a one-year STEM Master's program even if they completed a non-STEM Bachelor's degree. Either way, these results should be interpreted with caution.

To address concerns regarding the presence of confounding factors driving the rising pre-trends in Master's degree enrollments, we control for major-specific linear trends in our primary difference-in-differences analysis, reported in Panel A of Table 3. Results continue to indicate a positive and significant increase in Bachelor's and Master's enrollments following the OPT reforms. However, point estimates shrink substantially as major trends absorb much of the variation in enrollments. While they may help in accounting for pre-existing trends, the decline in point-estimates may also be attributable to the trends absorbing dynamically evolving treatment effects (*e.g.* Wolfers, 2006; Freyaldenhoven, Hansen and Shapiro, 2019).

In addition, the observed pre-existing trends for Master's programs might be driven by unobserved or unaccounted for macroeconomic factors at home and/or in the United States (*e.g.* labor demand shocks, changing returns to education, university capacity constraints) that overlapped with the OPT reforms. Of first order concern is the overlap of the first OPT extension of 2008 with the Great Recession, which could have impacted STEM and non-STEM enrollments differently, by altering the demand for such skills and, in turn, the returns to those educational investments. A way to check if this was the case is to account for major-specific unemployment rates capturing changing economic conditions within the United States.[14] Panel B of Table 3

[14] We construct major specific unemployment rates by first calculating unemployment rates in each SOC occupation for the years of analysis (2004-2016), from the American Community Surveys. We then use a crosswalk from SOC

provides the results from such an exercise. Based on the estimates displayed therein, our findings prove robust to the inclusion of these controls, with point estimates that are only slightly smaller from those in Table 2.

Another way to gauge the influence of the Great Recession, would be to separately examine the impact of the various OPT reforms. If the results from Table 2 were entirely a byproduct of the 2008 Great Recession, the later OPT reforms of 2011 and 2012 should have a null impact on international student enrollments. To separately measure the impact of the 17-month extension and the expansion of STEM designated-degree programs in 2011 and 2012, we create three dummy variables that identify which reform each major belonged to. These OPT reform indicators are then interacted with their respective dummies for post treatment years (*i.e.* 2008, 2011, or 2012). We include all these interactions in the model, along with the baseline controls shown in equation (9).

Panel C in Table 3 displays the estimated impact of each OPT reform on the matriculation of international students in Bachelor's and Master's programs. As can be seen therein, the 2008 OPT reform had the smallest impact of the three OPT reforms in expanding the volume of international graduates, raising the enrollments in Bachelor's degrees by 10 percent, and those in Master's by 25 percent. In contrast, the 2011 and 2012 OPT reforms rose the enrollments in Bachelor's programs by roughly 25 percent, and those in Master's program by 43 and 33 percent, respectively. Overall, the fact that the 2011 and 2012 reforms had larger (if not similar) impacts on international student enrollments suggests that the effect measured in Table 2 is unlikely to have been the byproduct of the 2008 Great Recession.

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occupation codes to 6-digit CIP codes, provided by the Department of Education (see: https://nces.ed.gov/ipeds/cipcode/resources.aspx?y=56). Because the crosswalk is a many-to-many crosswalk, we than average all SOC unemployment rates within a single 6-digit CIP code, to obtain the major specific unemployment rate for a given year.

To further assess the influence of the Great Recession in our estimates, we experiment with alternative control groups. Even though our preferred control group are Business majors given their similarities prior to the OPT reforms, we recognize that these students may have been disproportionately affected by the Great Recession. Additionally, STEM fields might be regarded as closer substitutes for Business than non-STEM fields such as Art, Music or History. If that is the case, treatment effects of the OPT reforms may be overstated. To address this concern, we first experiment with expanding the control group to include other non-STEM majors in column (1) of Table 4. Next, in column (2), we exclude Business students and keep all other non-STEM majors. Finally, in column (3), we construct a synthetic control group.[15] As can be seen in Table 4, except for Business majors, results in columns (1) and (2) are suggestive of larger treatment effects. Results using the synthetic control (column (3)) are closer to those obtained in Table 2. Either way, however, the estimates in Table 4 consistently support the notion that the OPT reforms encouraged international student enrollments in STEM.

Finally, we experiment with using native-born STEM enrollments as a control. Table 5 incorporates data from the National Survey of College Graduates (NSCG), which provides information on native students that completed their degrees. We aggregate native students into major and start year cells—as our focus is on the appropriateness of the control group, we drop the gender dimension for simplification. There are numerous shortcomings to using natives as a control group. For instance, NSCG data becomes less representative of enrollments in later years

[15] The synthetic major is constructed using the synthetic control method and consists of all the non-zero weighted non-STEM majors. For the Bachelor's, these majors and their CIP codes are Natural Resource Economics (03.0204), Forestry, Other (03.0599), Computer and Information Sciences and Support Services, Other (11.9999), Bilingual and Multilingual Education (13.0201), Pharmacy, Pharmaceutical Sciences, and Administration, Other (51.2099), Logistics and Materials Management (52.0203), Finance and Financial Management Services, Other (52.0899), Insurance (52.1701). For the Master's, these majors and their CIP codes are Natural Resource Economics (03.0204), Urban Education and Leadership (13.0410), Economics, Other (45.0699), Logistics and Materials Management (52.0203), Investments and Securities (52.0807), Finance and Financial Management Services, Other (52.0899), Construction Management (52.2001).

due to non-completion. Therefore, we can only gauge the impact of the 2008 OPT reform. To that end, we use data on enrollments from 2004 through 2011. Hence, difference-in-differences estimates compare enrollments of international and native students in eligible STEM majors, before and after the 2008 reform. For each degree level, we then display the estimates from our baseline specification. The first one uses all natives as a control group, the second one uses only white natives as the control group.

Using natives as a control group substantially raises the estimated impact of the OPT reforms on international student enrollments in Bachelor's degrees in STEM fields. As opposed to increasing those enrollments by 17 percent (Table 2), we now observe STEM international enrollments in Bachelor's degree programs rising by a factor of 2 relative to STEM native enrollments in the same degree, regardless of which group of natives is used as a control. We obtain similar results if we focus on international student enrollments in Master's degrees. The OPT reforms seem to have increased those enrollments by 46 percent when compared to all native enrollments in a Master's degree in STEM fields, or by 60 percent when compared to alike enrollments of white natives. While the results using natives qualitatively support the earlier findings, the large size of point estimates suggests some caution in interpreting these estimates. Structural differences between natives and international students, likely stronger impacts of the Great Recession on natives, and possible differential sample attrition in later survey years of the NSCG, may all lead to inflated estimates. Nonetheless, we weigh the evidence on different control groups holistically. Regardless of the control group being used, the OPT reforms appear to have significantly increased international students' enrollments in STEM fields at both the Bachelor's and Master's degrees levels.

To conclude, we conduct a couple of placebo tests to assess the role played by confounding factors, including changes in the demand for STEM labor at home or in the United States, in the observed increase in international STEM enrollments in Bachelor's and Master's degree programs. If, for example, changes in the demand for STEM labor, were responsible for the documented impacts, we would expect similar increases in STEM international enrollments in Associate's and Doctoral degree programs. Yet, as noted earlier, students enrolled in these two programs should have been less responsive, or not responsive at all, to the OPT extensions.[16] Table 6 examines if that was the case, by performing the same analysis for Associate's and Doctoral degree entrants. As can be seen therein, international student enrollments in Associate degree programs did not significantly change following the OPT reforms. While international student enrollments in Doctoral programs show some increase when estimating our baseline model (column 3), the impacts of the OPT reforms dissipates once we include major specific time trends in column (4). These placebo checks suggest that impacts of OPT reforms on Bachelor's and Master's enrollments, from Table 2, were unlikely to be solely driven by confounding factors, such as the economic downturn and labor demand shocks affecting STEM and Business majors differentially.

**B) Selectivity**

The OPT policies might not have only altered enrollments, but also their composition. To explore this possibility, we make use of international student data from SEVIS and institutional information from IPEDS.[17] Specifically, to learn about potential selection effects stemming from the OPT reforms, we explore the impact of the OPT reforms on international students' enrollments

[16] After all, a large benefit of the OPT extension was to be able to enter more than once in the H1-B visa lottery. Yet, Associate degree holders do not qualify for an H1-B visa, and PhD holders have access to an unlimited number of H1-B visas if employed in academia.

in STEM based on several institutional traits –some of which can be interpreted as indicators of *quality*, as well as on the institutional support to students.

Table 7 reports our findings based on the type of institutional control and the institution's Carnegie classification. According to the estimates in Panel A of Table 7, the OPT reforms resulted in significant enrollment growth in STEM in both public and private not-for-profit institutions. In the former, enrollments in Bachelor's and Master's programs rose by 11 percent and 27 percent, respectively; but the growth was also significant among private not-for-profit institutions, where enrollments in Bachelor's and Master's programs grew by a similar 11 percent and 22 percent, correspondingly.

If we focus on the Carnegie classification of institutions attended by international students (Panel B of Table 7), we observe significant STEM enrollment growth in institutions with high research activity (Research I and II universities), where international student enrollments in Bachelor's and Master's programs grew by 13 percent and 29 percent, respectively, with the OPT reforms. Master's institutions, which generally do not offer degrees beyond the Master's level, also sustained an increase in international enrollments in Master's degree programs of 16 percent.[18]

Next, we utilize other measures that may better capture the selectivity of individual students, including the admissions rate and available funds per student of the institution attended, and the amount of financial support students receive. In Panel A of Table 8, we group institutions into categories of selectivity based on whether their admission rates fell within the first, second, third or fourth quartile of the distribution. Lower values of admissions rates are more selective.

[18] We categorize IPEDS institutions according to the 2005 Basic Carnegie Classification definition. In Panel B of Table 7, the research group includes Research Universities (very high research activity), Research Universities (high research activity), and Doctoral/Research Universities; the Master's group includes Master's Colleges and Universities (larger programs), Master's Colleges and Universities (medium programs), and Master's Colleges and Universities (smaller programs); the Baccalaureate group includes Baccalaureate Colleges, Associate's, and Special Focus Institutions.

As can be seen therein, international student enrollments in Bachelor's degrees grew the most among the most selective institutions, whereas they dropped among the least selective institutions. In a similar vein, we observe much larger increases in international student enrollments in Master's programs in institutions in more selective institutions, than at the least selective institutions.

In panel B of Table 8, we use a different measure of institution quality–namely, its available funds per student.[19] Once more, we group universities into quartiles based on this measure, with higher values of funds per student indicating greater selectivity. Once more, international student enrollments in STEM Bachelor's degrees appear to have grown the most in very selective universities. In the case of Master's degree programs, we observe significant increases in international student enrollments in all institutions, except for the least selective. However, the largest growth in enrollments is observed among the very selective institutions, hinting once more on the OPT reforms potentially raising the quality of international student enrollments.

Finally, in Panel C of Table 8, we gauge the impact of the OPT reforms on international student enrollments in Bachelor's and Master's degrees according to the financial support students received from scholarships, fellowships and other funds received from the university they attend or other external sources. Again, as with admission rates and the available funds per student, the estimates are suggestive of international student enrollments rising, primarily, among very selective students as captured by those receiving the largest financial support.[20] This is particularly true for enrollments in Bachelor's degree programs, where the reforms appear to have raised

[19] Total funds available to each student is calculated using an institution's total revenue in 2004 Fiscal Year (excluding tuition and fees) divided by its total number of enrollment. Total revenue as reported in IPEDS includes tuition and fees, government appropriations, grants and contracts, contributions from affiliated entities, investment return, sales and services of educational activities and auxiliary enterprises, and other revenue.

[20] Student financial support measures the proportion of financial support a student received from school or other external source out of all sources of finance (i.e any external funds and student own personal funds). All funds are denominated to 2004 which is the year the sample period starts.

enrollments by 14 percent among very selective students, while raising alike enrollments in the least selective tier by a marginally statistically significant 6 percent. In the case of Master's degree programs, we observe increases in international student enrollments across the board. Yet, the enrollment impacts among the least selective tier average 12.5 percent, whereas they reach 30 percent among the very selective tier.

Overall, these results in Table 7 and 8 are suggestive of OPT reforms raising the quality of international student enrollments, as captured by the traits of the institutions they attend–namely, not-for-profit research and Master's institutions with lower admission rates and more funds per student, as well as by the amount of financial support received by students.

## VII. Summary and Conclusions

The United States remains the top host of international students globally. This paper examines how policies affecting the return to studying in the United States might affect international student enrollments –both in terms of scale and selectivity. Specifically, we examine the impact of the 2008, 2011 and 2012 OPT policy changes, which lengthened the training period of international graduates in STEM fields from 12 to 29 months, and expanded the list of eligible STEM majors, respectively. Using a difference-in-differences design that compares international STEM majors to non-STEM majors (and/or native STEM majors), we find positive treatment effects on both scale and selection. Specifically, the OPT reforms raised international student enrollments in Bachelor's and Master's programs by 17 and 30 percent, respectively, and increased the quality of students as captured the traits of the institutions they attend –namely, not-for-profit research and Master's institutions with lower admission rates and more funds per student; and by the financial support received by students attending those institutions.

International students have a significant impact on the United States. In 2017, they contributed $42.4 billion through tuition, room and board, and other expenses, according to the U.S. Department of Commerce. More importantly, the presence of more STEM graduates in the workforce significantly raises wages of other college-educated individuals in the metropolitan area (Peri, Shih and Sparber, 2015). These findings are in line with those from prior studies informing about the positive impacts that international college graduates can have on their local economies by facilitating the adoption of better technologies and the sharing of knowledge and ideas –all of which can positively impact productivity and average wages in the cities where they reside (*e.g.* Moretti, 2004a, 2004b; Iranzo and Peri, 2009; Whalley, 2014). In this regard, several authors have shown that, despite accounting for just 12 percent of the United States population in 2000, 26 percent of US-based Nobel Prize recipients from 1990–2000 were immigrants (Anderson, 2016). Immigrants are also over-represented among members of the National Academy of Sciences and the National Academy of Engineering, and they frequently found biotech companies undergoing initial public offerings (IPOs) (Stephan and Levin, 2001). Finally, immigrants play a key role in the patenting of ideas. Wadhwa *et al.* (2007) document how 24 percent of international patent applications in the United States, and Hunt and Gauthier-Loiselle (2010) show how increases in the share of immigrant college graduates raises patents per capita by 9–18 percent. Given these positive impacts and externalities, gaining a better understanding of how immigration policy can help attract more and possibly higher quality international students seems only logical.

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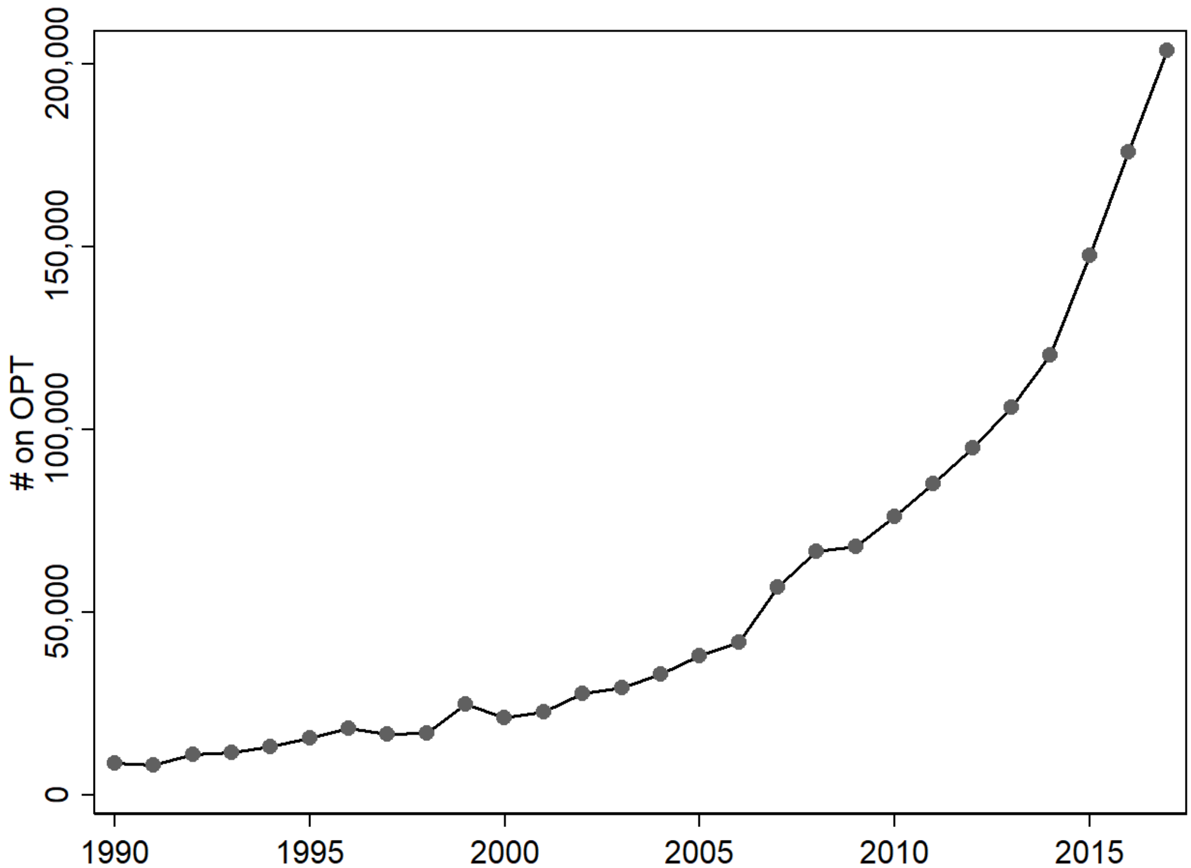
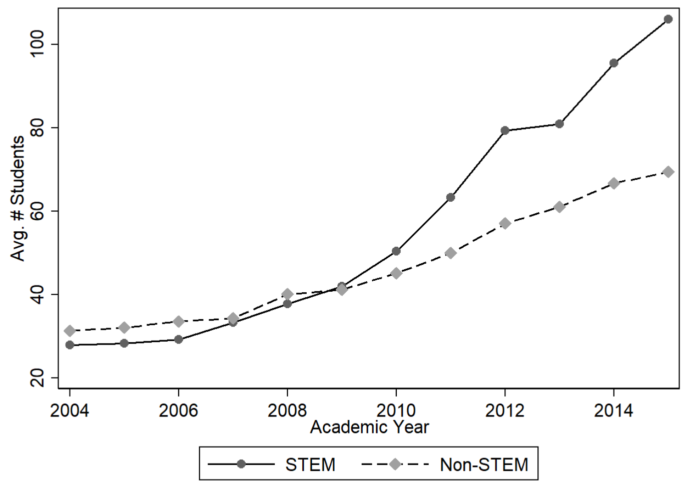
Figure 1: International Students on OPT, 1990-2017

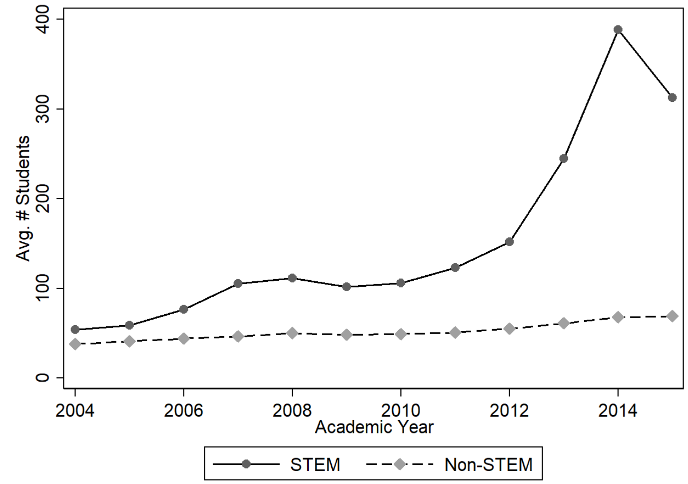



Notes: Figures plots total number of international students using the OPT program by year. Data from the Institute of International Education, accessed from: https://opendoorsdata.org/data/international-students/.

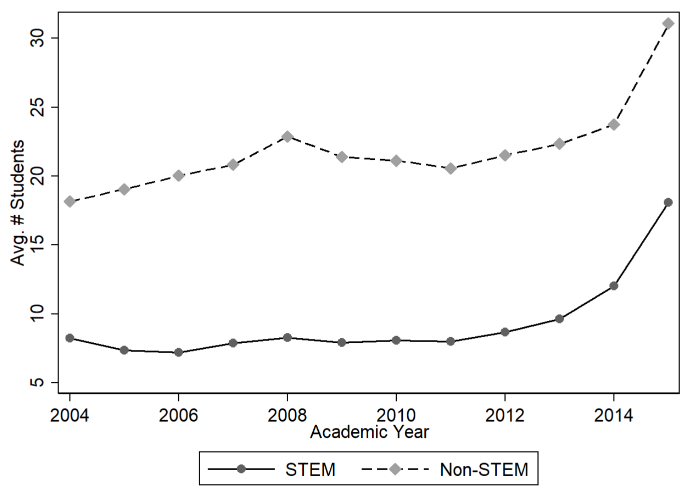
Figure 2: STEM vs. Non-STEM Enrollments by Level



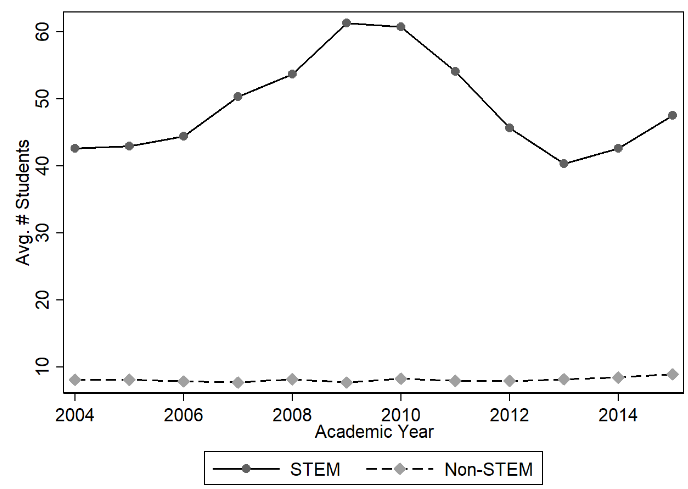

(a) Bachelor's




(b) Master's



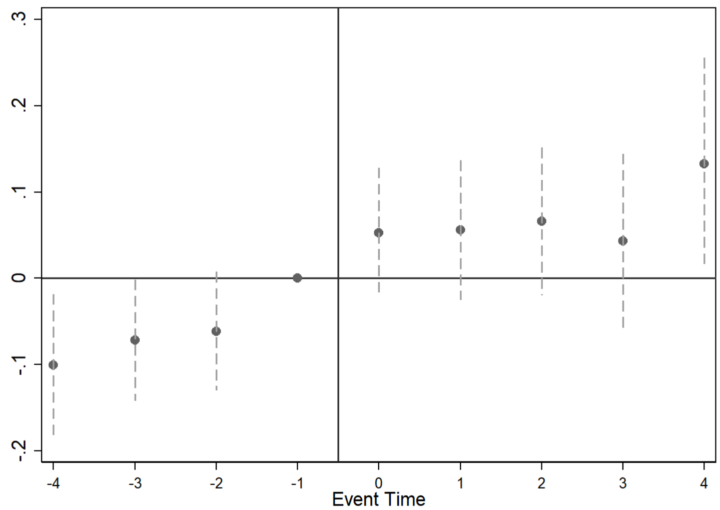

(c) Associate's



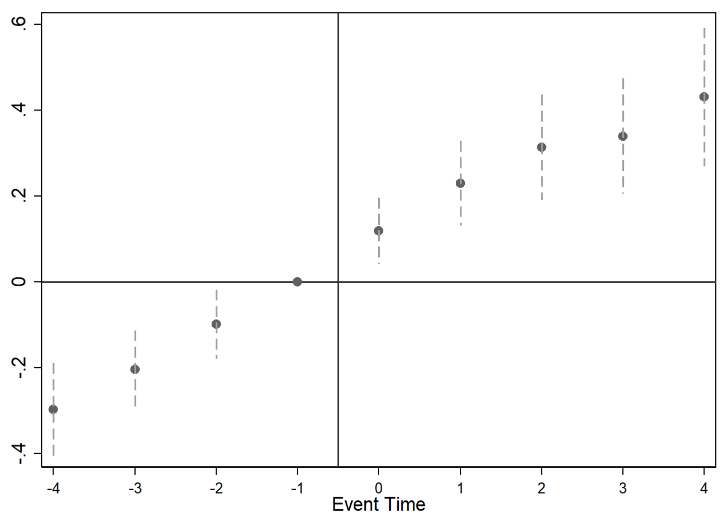

(d) Doctorate

Notes: Figure shows average starting enrollment for each academic year across STEM and non-STEM majors and also by academic level. Total international student enrollment is calculated for each major, which is defined by a 6-digit CIP code. These counts are then averaged across STEM and non-STEM majors.

Figure 3: STEM vs. Non-STEM Enrollments by Level




(a) Bachelor's




(b) Master's

Notes: Figure shows average starting enrollment for each academic year across STEM and non-STEM majors and also by academic level. Total international student enrollment is calculated for each major, which is defined by a 6-digit CIP code. These counts are then averaged across STEM and non-STEM majors.

Table 1: Summary Statistics of Internatioal Students 2004-2007

| | (1) STEM | (2) Business | (3) Diff. (2)-(1) | (4) Other Non-STEM | (5) Diff. (3)-(1) |
|---|---|---|---|---|---|
| F-1 Visa | 1.00 | 1.00 | | 1.00 | |
| | (0.00) | (0.00) | | (0.00) | |
| | | | 0.00 | | 0.00 |
| Male | 0.71 | 0.58 | | 0.42 | |
| | (0.46) | (0.49) | | (0.49) | |
| | | | -0.14*** | | -0.29*** |
| Age at Entry | 24.47 | 24.89 | | 25.53 | |
| | (4.16) | (5.03) | | (6.34) | |
| | | | 0.39*** | | 1.16*** |
| China/India | 0.52 | 0.21 | | 0.12 | |
| | (0.50) | (0.41) | | (0.32) | |
| | | | -0.31*** | | -0.39*** |
| Associate's | 0.00 | 0.02 | | 0.02 | |
| | (0.05) | (0.14) | | (0.15) | |
| | | | 0.10*** | | 0.14*** |
| Bachelor's | 0.23 | 0.46 | | 0.46 | |
| | (0.42) | (0.50) | | (0.50) | |
| | | | 0.17*** | | 0.16*** |
| Master's | 0.46 | 0.50 | | 0.36 | |
| | (0.50) | (0.50) | | (0.48) | |
| | | | -0.00* | | -0.14*** |
| Doctorate | 0.31 | 0.02 | | 0.15 | |
| | (0.46) | (0.15) | | (0.36) | |
| | | | -0.27*** | | -0.16*** |
| Duration | 3.16 | 2.35 | | 2.78 | |
| | (1.90) | (1.35) | | (1.78) | |
| | | | -0.75*** | | -0.40*** |
| Selective Institution | 0.36 | 0.37 | | 0.43 | |
| | (0.48) | (0.48) | | (0.49) | |
| | | | 0.01*** | | 0.07*** |
| Monthly Expenses ($) | 2976.13 | 3275.64 | | 3317.50 | |
| | (25230.20) | (2218.18) | | (36451.68) | |
| | | | 100.58* | | 121.56 |
| Monthly Funds ($) | 3392.20 | 3919.84 | | 3767.12 | |
| | (25165.13) | (12432.55) | | (20973.48) | |
| | | | 280.99*** | | 247.06*** |
| OPT | 0.67 | 0.47 | | 0.37 | |
| | (0.47) | (0.50) | | (0.48) | |
| | | | -0.22*** | | -0.32*** |
| Students | 228,203 | 157,730 | 385,933 | 251,292 | 479,495 |

Notes: Table provides summary statistics of international students from SEVIS using years prior to the 2008 OPT reform, 2004-2007. The STEM majors are those on the list of approved for the OPT extensions in 2008, 2011 and 2012. Business majors and Other non-STEM majors are those that are ineligible. * p<0.10, ** p<0.05, *** p<0.01,

Table 2: Difference-in-differences Results on Enrollment, by Level and Gender

| | (1) All | (2) Male | (3) Female |
|---|---|---|---|
| **A: Bachelor's** | | | |
| treat | 0.167*** | 0.208*** | 0.126** |
| | (0.036) | (0.050) | (0.050) |
| Obs | 12,035 | 5,995 | 6,040 |
| M-G Cells | 949 | 474 | 475 |
| Y Mean | 1.62 | 1.81 | 1.44 |
| **B: Master's** | | | |
| treat | 0.304*** | 0.330*** | 0.279*** |
| | (0.048) | (0.068) | (0.068) |
| Obs | 12,035 | 5,995 | 6,040 |
| M-G Cells | 949 | 474 | 475 |
| Y Mean | 1.96 | 2.03 | 1.89 |

Notes: Table shows difference-in-differences estimates of the impact of the OPT reforms. International enrollments in STEM fields are considered the treated group, while international enrollments in Business fields serve as the control. Results are shown for all enrollments, and separately for male and females. Enrollments are specified in inverse hyperbolic sine. Specifications include major-by-gender fixed effects and cohort-by-gender dummies. Standard errors are clustered at the major-gender level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Table 3: Robustness Checks for Confounding Factors

| | (1) Bachelor's | (2) Master's |
|---|---|---|
| **A: Control for Major Trends** | | |
| treat | 0.061** | 0.229*** |
| | (0.031) | (0.042) |
| Obs | 12,035 | 12,035 |
| M-G Cells | 949 | 949 |
| Y Mean | 1.62 | 1.96 |
| **B: Control for Unemployment Rate** | | |
| treat | 0.134*** | 0.272*** |
| | (0.037) | (0.050) |
| Obs | 11,206 | 11,206 |
| M-G Cells | 885 | 885 |
| Y Mean | 1.64 | 1.99 |
| **C: Distinguish Various OPT Reforms** | | |
| postXstem08 | 0.096** | 0.252*** |
| | (0.046) | (0.056) |
| postXstem11 | 0.250** | 0.431*** |
| | (0.101) | (0.107) |
| postXstem12 | 0.241*** | 0.330*** |
| | (0.075) | (0.113) |
| Obs | 12,035 | 12,035 |
| M-G Cells | 949 | 949 |
| Y Mean | 1.62 | 1.96 |

Notes: Table shows difference-in-difference results under various robustness checks. Panel A includes major-specific linear trends. Panel B includes major-specific unemployment rates, calculated by linking occupation specific unemployment rates, to majors using an occupation-major crosswalk. Panel C displays regression results that separately examine the effect of the 2008 policy, which extended the work duration, and the 2011 and the 2012 policy which expanded the list of eligible STEM majors. Enrollments are specified in inverse hyperbolic sine. Specifications include major-by-gender fixed effects and cohort-by-gender dummies. Standard errors are clustered at the major-gender level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Table 4: Robustness Checks using Different Control Groups

| | (1) Control Group: All Non-STEM | (2) Control Group: Non-Business | (3) Control Group: Synthetic Non-STEM |
|---|---|---|---|
| **A: Bachelor's** | | | |
| treat | 0.324*** | 0.332*** | 0.118*** |
| | (0.031) | (0.031) | (0.037) |
| Obs | 37,830 | 35,909 | 10,322 |
| M-G Cells | 2,910 | 2,795 | 794 |
| Y Mean | 1.20 | 1.12 | 1.45 |
| **B: Master's** | | | |
| treat | 0.453*** | 0.466*** | 0.253*** |
| | (0.040) | (0.040) | (0.048) |
| Obs | 37,830 | 35,909 | 10,296 |
| M-G Cells | 2,910 | 2,795 | 792 |
| Y Mean | 1.41 | 1.33 | 1.83 |

Notes: Table shows difference-in-differences estimates using different control groups. Column 1 uses all non-STEM majors in the control group. Column 2 uses only non-business non-STEM majors as the control group. Column 3 control group is a synthetic non-STEM major constructed by the synthetic control approach. Enrollments are specified in inverse hyperbolic sine. Specifications include major-by-gender fixed effects and cohort-by-gender dummies. Standard errors are clustered at the major-gender level. * p<0.10, ** p<0.05, *** p<0.01.

Table 5: Robustness Checks using Native STEM Students

| | Bachelor's | | Master's | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| DD, '08 Reform, Control: All Natives | 1.927*** | | 0.464*** | |
| | (0.283) | | (0.147) | |
| DD, '08 Reform, Control: White Natives | | 2.200*** | | 0.597*** |
| | | (0.264) | | (0.183) |
| Obs | 726 | 726 | 726 | 726 |
| M-G Cells | 45 | 45 | 45 | 45 |
| Y Mean | 6.00 | 5.79 | 5.76 | 5.65 |

Notes: Table shows results of robustness checks on bachelor's enrollments. Panel A uses Native enrollments in STEM fields as a control group, from the NSCG. Controls include a gender group dummy, cohort-by-major fixed effects and group (native/foreign)-by-major fixed effects. International enrollment come from SEVIS. We use all native-born students, and also White native-born students. Standard errors are clustered by major-gender cells. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Table 6: Placebo Checks Using Associate and Doctoral Degree Enrollment

| | Associate's | | Doctorate | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | Base | +Major Trends | Base | +Major Trends |
| treat | -0.032 | -0.026 | 0.055** | 0.008 |
| | (0.030) | (0.023) | (0.027) | (0.031) |
| Obs | 12,035 | 12,035 | 12,035 | 12,035 |
| M-G Cells | 949 | 949 | 949 | 949 |
| Y Mean | 0.89 | 0.89 | 1.44 | 1.44 |

Notes: Table shows difference-in-differences estimates of the impact of OPT reforms. International enrollments in STEM fields are considered the treated group, while international enrollments in Business serve as the control. Results are shown for enrollment in Associate's and Doctoral programmes, separately. Enrollments are transformed with inverse hyperbolic sine, to approximate logs and include cells with 0. Specifications include major fixed effects and cohort-by-gender dummies. Standard errors are clustered at the major-gender level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Table 7: Diff-in-diff Estimates of Enrollment by Institution Type

| | Bachelor's | | | Master's | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| **A: Institution Control** | *Public* | *Private* | *For-Profit* | *Public* | *Private* | *For-Profit* |
| treat | 0.112*** | 0.115*** | -0.015 | 0.270*** | 0.223*** | 0.020 |
| | (0.034) | (0.033) | (0.017) | (0.042) | (0.048) | (0.023) |
| Obs | 12,035 | 12,035 | 12,035 | 12,035 | 12,035 | 12,035 |
| M-G Cells | 949 | 949 | 949 | 949 | 949 | 949 |
| Y Mean | 1.26 | 0.95 | 0.18 | 1.45 | 1.29 | 0.16 |
| **B: Carnegie Classification** | *Research* | *Master's* | *Baccalaureate* | *Research* | *Master's* | *Baccalaureate* |
| treat | 0.127*** | -0.001 | 0.044* | 0.294*** | 0.156*** | -0.002 |
| | (0.034) | (0.028) | (0.025) | (0.049) | (0.038) | (0.018) |
| Obs | 12,035 | 12,035 | 12,035 | 12,035 | 12,035 | 12,035 |
| M-G Cells | 949 | 949 | 949 | 949 | 949 | 949 |
| Y Mean | 1.22 | 0.80 | 0.48 | 1.63 | 0.93 | 0.14 |

Notes: Estimates are based on SEVIS international enrollments and IPEDS institutional information. The sample covers years 2004-2016. Students of bachelor's and master's degree programs are included in the analysis and the durations of study are restricted to 3-6 years for BAs, 1-3 years for MAs. Dependent variable is the inverse hyperbolic sine of students in a specified type of institution in the gender-year-major cell. All specifications also include gender, year, major fixed effects. Standard errors are clustered at the major level. Standard errors in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

Table 8: Diff-in-diff Estimates of Enrollment by Institution and Student Ranking

| | Bachelor's | | | | Master's | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) Least Selective | (2) Less Selective | (3) Selective | (4) Very Selective | (5) Least Selective | (6) Less Selective | (7) Selective | (8) Very Selective |
| **A: School Admissions Rate** | | | | | | | | |
| treat | -0.071*** | 0.063** | 0.114*** | 0.109*** | 0.054** | 0.219*** | 0.202*** | 0.188*** |
| | (0.025) | (0.031) | (0.032) | (0.031) | (0.027) | (0.038) | (0.041) | (0.050) |
| Obs | 12,035 | 12,035 | 12,035 | 12,035 | 12,035 | 12,035 | 12,035 | 12,035 |
| M-G Cells | 949 | 949 | 949 | 949 | 949 | 949 | 949 | 949 |
| Y Mean | 0.49 | 0.82 | 0.96 | 0.85 | 0.48 | 0.89 | 1.17 | 1.18 |
| **B: School Funds per Student** | | | | | | | | |
| treat | -0.001 | 0.012 | 0.004 | 0.149*** | -0.035 | 0.115*** | 0.161*** | 0.284*** |
| | (0.017) | (0.024) | (0.030) | (0.035) | (0.022) | (0.031) | (0.043) | (0.050) |
| Obs | 12,035 | 12,035 | 12,035 | 12,035 | 12,035 | 12,035 | 12,035 | 12,035 |
| M-G Cells | 949 | 949 | 949 | 949 | 949 | 949 | 949 | 949 |
| Y Mean | 0.20 | 0.55 | 0.78 | 1.27 | 0.21 | 0.60 | 0.96 | 1.59 |
| **C: Student Financial Support** | | | | | | | | |
| treat | 0.056* | -0.003 | 0.013 | 0.144*** | 0.125*** | 0.130*** | 0.123*** | 0.295*** |
| | (0.029) | (0.017) | (0.016) | (0.034) | (0.043) | (0.025) | (0.026) | (0.044) |
| Obs | 12,035 | 12,035 | 12,035 | 12,035 | 12,035 | 12,035 | 12,035 | 12,035 |
| M-G Cells | 949 | 949 | 949 | 949 | 949 | 949 | 949 | 949 |
| Y Mean | 0.68 | 0.22 | 0.22 | 1.50 | 1.04 | 0.34 | 0.40 | 1.77 |

Notes: Estimates are based on SEVIS international enrollments and IPEDS institutional information. The sample covers years 2004-2016. Dependent variable is the inverse hyperbolic sine of students in a specified type of category in the gender-year-major cell. All specifications also include gender, year, major fixed effects. Standard errors are clustered at the major level. Standard errors in parentheses. Admissions rates from very selective to the least selective are: 1st quartile 0%-57%, 2nd quartile 57%-73%, third quartlie 73%-86%, 4th quartile above 86%. School funds per student measures the total funds per student held by a school in 2004 Fiscal Year. Ranges of funds from the least selective to very selective are: 1st quartile $0-$4,168, 2nd quartile $4,168-$13,514, 3rd quartile $13,514-$55,626. 4th quartile above $55,626. Student financial support measures the ratio of external support a student received out of all sources of finance (i.e. the ratio is external support from school or other sources out of external and own sources of finance). From the least selective to very selective, the ratios are: less than 25%, between 25% and 50%, between 50% and 75%, and greater than 75%. * p<0.10, ** p<0.05, *** p<0.01.