# The Impact of Work Permission Policies on Foreign Graduation

by

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in

Economics

KOÇ ÜNİVERSİTESİ

July 31, 2024

# The Impact of Work Permission Policies on Foreign Graduation

Koç University

Graduate School of Social Sciences and Humanities

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**Yeşim Yurteri**

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Date: 31.07.2024

# ABSTRACT

**The Impact of Work Permission Policies on Foreign Graduation**

**Yeşim Yurteri**

**Master of Arts in Economics**

**July 31, 2024**

Countries often use visa policies to attract foreign talent in the fields of science, technology, engineering, and mathematics (STEM). The Optional Practical Training (OPT) program attracts high-skilled students and prospective workers by granting a 12-month U.S. work authorization to foreign graduates of U.S. institutions. In 2008, the U.S. government extended the OPT duration to 29 months for foreign graduates of STEM programs. This thesis examines the impacts of this OPT extension policy on the number of international students graduating with a STEM degree from U.S. universities and colleges. Using data from the Integrated Postsecondary Education Data System (IPEDS), we focus on the impact at both the bachelor's and master's levels. Identifying the effects of the OPT extension on student migration is methodologically challenging due to the upward trend in the enrollment of international students, driven particularly by certain origin countries. The standard two-way fixed effects (TWFE) difference-in-differences (DD) analysis, with all non-STEM programs as our control group, shows that the OPT reform increases foreign graduation by 16% at the bachelor's level and 45% at the master's level. However, when the control group is constructed via the synthetic control method (SCM), by closely matching the characteristics of the treated programs in our sample, the two-way fixed effects regressions show that the OPT reform does not affect foreign graduation at the bachelor's level and increases it by only 29% at the master's level. We also find that the impact of the OPT reform on foreign graduation varies greatly based on program characteristics. The past networks of programs, in terms of the origin of foreign students, and their selectivity affect the size of the effect of the OPT policy, yet the local economic conditions do not. Particularly, the impact of the OPT is larger for STEM programs that attracted more students from Asia in the pre-policy period and for more selective programs.

# ÖZETÇE

**Çalışma İzni Politikalarının Yabancı Öğrenci Mezuniyeti Üzerine Etkisi**

**Yeşim Yurteri**

**Ekonomi, Yüksek Lisans**

**31 Temmuz 2024**

Genellikle birçok ülke bilim, teknoloji, mühendislik ve matematik (STEM) alanlarındaki yabancı yeteneklerde ilgi uyandırmak için vize politikalarını kullanır. İsteğe Bağlı Pratik Eğitim (OPT) programı, ABD kurumlarından mezun olan yabancı öğrencilere, ABD'de 12 aylık çalışma izni vererek yüksek nitelikli öğrencilerin ve gelecekteki çalışanların dikkatini çekmektedir. 2008 yılında, ABD hükümeti, STEM programlarından mezun olan yabancı öğrencilerin OPT süresini 29 aya uzattı. Bu tez, OPT süre-uzatma politikasının ABD üniversitelerinden STEM diploması alarak mezun olan uluslararası öğrenci sayısı üzerindeki etkilerini incelemektedir. Entegre Lisansüstü Eğitim Verileri Sistemi'ndeki verilerini kullanarak hem lisans hem de yüksek lisans düzeyindeki etkileri inceliyoruz. Belirli ülkelerden gelen uluslararası öğrenci kayıtlarındaki artış nedeniyle, OPT süre-uzatmasının öğrenci göçü üzerindeki etkilerini ölçmek metodolojik olarak zordur. Standart iki yönlü sabit etkiler farkların farkı analizi, tüm STEM dışı programları kontrol grubu olarak alarak, OPT reformunun lisans seviyesinde uluslararası öğrenci mezuniyetini 16% ve yüksek lisans seviyesinde ise 45% oranında artırdığını göstermektedir. Ancak, sentetik kontrol yöntemi ile deney grubundaki programların özelliklerini yakından eşleştirerek kontrol grubu oluşturulduğunda, iki yönlü sabit etkiler regresyonları, OPT reformunun lisans seviyesinde uluslararası öğrenci mezuniyetini etkilemediğini ve yalnızca yüksek lisans seviyesinde 29% oranında arttırdığını göstermektedir. Ayrıca, OPT reformunun uluslararası öğrenci mezuniyeti üzerindeki etkisinin program özelliklerine göre büyük ölçüde değiştiğini gözlemliyoruz. Programların geçmiş çevre ağları, yabancı öğrencilerin kökeni ve programların seçiciliği, OPT reformunun etkisinin büyüklüğünü etkilerken, yerel ekonomik koşullar etkilememektedir. Özellikle, OPT etkisi, reform öncesi dönemde Asya'dan daha fazla öğrenci sayısına sahip STEM programları ve daha seçici programlar için daha büyüktür.

# ACKNOWLEDGMENTS

I extend my deepest gratitude to my advisor Assistant Professor Murat Demirci, whose guidance, unwavering support, and insightful feedback have been indispensable throughout my research. I am grateful to the faculty and staff of the Department of Economics at the Graduate School of Social Sciences and Humanities at Koç University, for their assistance and the supportive academic environment. I also thank TÜBİTAK for providing generous financial support under Project No 122K054. I feel extremely fortunate to complete my studies alongside my cohort members, whose help and moral support helped me reach my highest potential. Lastly, I thank my family and friends for their constant support and encouragement in following my dreams.

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# ABBREVIATIONS

| | |
|---|---|
| ACT | American College Test |
| BEA | Bureau of Economic Analysis |
| BEF | Business, Economics, and Finance |
| BLS | Bureau of Labor Statistics |
| CIP | Classification of Instructional Programs |
| CPS | Current Population Survey |
| DD | Difference-in-Differences |
| DHS | Department of Homeland Security |
| GDP | Gross Domestic Product |
| IPEDS | Integrated Postsecondary Education Data System |
| LAUS | Local Area Unemployment Statistics |
| NCES | National Center for Education Statistics |
| OEWS | Occupational Employment and Wage Statistics |
| OPT | Optional Practical Training |
| SCM | Synthetic Control Method |
| SEVP | Student Exchange and Visitor Program |
| SOC | Standard Occupational Classification |
| STEM | Science, Technology, Engineering, and Mathematics |
| TWFE | Two Way Fixed Effects |

# Chapter 1:
# INTRODUCTION

International students, especially graduates of Science, Engineering, Technology, and Mathematics (STEM) fields are essential to driving technological innovation and economic growth. Consequently, the primary goal of various countries is to attract high-skilled international students due to their potential positive impact on the host country's economy. The total number of international students graduating from U.S. universities and colleges rose from 215,718 in 1995 to 596,030 in 2019 (the IPEDS completion surveys). Notably, during this period, approximately 40% (the IPEDS completion surveys) of the total stock of international students in the United States completed their degrees in a STEM field.

After graduation, international students have two visa options to receive work authorization in the United States: The first option is to apply for the Optional Practical Training (OPT) program in the United States, which grants 12-month work permission in the U.S. labor market for any international student who holds an F-1 visa. The second option is to find a job with a visa sponsorship offer to enter the H1-B visa lottery. Winning the lottery is not guaranteed, whereas if students apply for OPT, they almost certainly get approval. Thus, the OPT policy is more reliable and consistent for international students' integration into the U.S. labor market.

In April 2008, the U.S. government extended the OPT duration by 17 months (12 to 29 months) for all eligible international degree holders in STEM fields. Following this extension, in 2011 and 2012, new STEM majors were included in the list of OPT extension-eligible STEM fields. In this study, we analyze how the work permit extension via OPT policies impacted the number of international students graduating with a STEM degree from U.S. colleges and universities at both bachelor's and master's levels. Using data from the Integrated Postsecondary Education Data System (IPEDS), we perform the two-way fixed effects (TWFE) difference-in-differences (DD) analysis by using non-STEM programs as a control group. The OPT reform increases foreign graduation by 16% percent at the bachelor's level and 45% at the master's level. However, there are noticeable differences in the characteristics of our treated vs. control groups in TWFE DD analysis. For instance, the share of students from countries that display large changes in terms of enrollment, such as China, India, and Saudi Arabia, is much lower in non-STEM programs compared to STEM programs in the pre-2008 period. International student migration has been on an upward trend in the United States, driven particularly by certain origin countries, potentially independent of the OPT policy STEM extension. Thus, it is methodologically challenging to identify the impact of the OPT extension on foreign graduation. We hypothesize that the standard DD analysis might provide a biased estimate of the OPT policy's impact, and we choose to use the Synthetic Control Method (SCM), initially developed by Abadie and Gardeazabal (2003) to generate our control group. The SCM constructs the controls by closely matching the characteristics of the treated programs in our sample. We match programs over their past network in foreign student origins and the level of foreign enrollment. Using the synthetically generated matches as a control group, we conduct a new set of TWFE DD analyses. As a result, we find that the OPT reform does not affect foreign graduation statistically at the bachelor's level and increases it by only 29% at the master's level. This analysis highlights the importance of constructing a control group that experiences similar qualities in the pre-treatment period.

Our next hypothesis is that the impact of the OPT reform on foreign graduation varies greatly based on program characteristics. Preliminary results show that the effects of the OPT extension on foreign graduation greatly vary across university types and fields. At the bachelor's level, we observe the largest impact at the research universities in mathematics (at both public and private universities), with foreign graduation increasing by 65.8% and 66.3%, respectively. In contrast, at the master's level, the largest effects are at the non-research universities in engineering (at both public and private universities), with foreign graduation increasing by 66.9% and 97.9%, respectively.

We conduct heterogeneity analyses regarding the following: 1) the program's network in foreign students' origin, 2) the economic characteristics of the local region where the program is located, and 3) university selectivity based on test scores. Our estimates show that the STEM programs that attracted more international students from Asia in the pre-OPT extension period have a larger impact of the OPT reform on foreign graduation. The university selectivity also increases the OPT's impact on foreign graduation, while the local economic conditions do not.

The paper consists of eight sections, including the introduction. Section 2 presents the findings of the current literature and explains our contributions. Section 3 provides a brief background information on U.S. visa and OPT procedures. Section 4 introduces the data used and presents summary statistics. Section 5 presents the methodology. Section 6 presents regression results and section 7 provides heterogeneity analyses. Finally, section 8 concludes.

# Chapter 2:
# LITERATURE REVIEW

Visa policies might affect the quantity and quality of international students coming to the United States to pursue their postsecondary education, with a strand of the literature analyzing these effects. Kato and Sparber (2013) examine the impact of the H1-B quota reductions on the quality of international students coming to study in the United States. They find an adverse effect of the H1-B policy change on the "quality" of incoming international students, by using the SAT scores and GPAs as ability measures. Shih (2016) examines whether the quantity of international students is influenced by the openness of the U.S. labor market, measured by the H-1B visa cap restriction enacted in 2003. He finds a positive relationship between international student enrollment and HB-1 visa issuances, showing that the H1-B caps restriction induced a 10% fall in the enrollment of international students. Specifically, the gravity regressions show that international student enrollment responds to H1-B visa issuance up to 3 years prior. Chen et al. (2023) find that international enrollment also responds to the anticipated F-1 visa refusal rate in the United States. Through the compilation of a unique dataset at the student level, containing SAT takers' detailed application information and F-1 visa refusal rates, Chen et. al. (2023) find that higher F-1 visa refusal rates decrease not only the number of international students taking the SAT but also the likelihood of these students to send their scores to U.S. institutions. In addition, they observe that the refusal rates have a larger impact on high-scoring international students. Amuedo-Dorantes et. al. (2023) examine the OPT extension's impact on the enrollment rates of international students in STEM fields. Using non-STEM fields as the control group, they find positive treatment effects on the number of international students. Specifically, the number of international students increases by 18% at the bachelor's level and 30% at the master's level.

Post-graduation policies, such as OPT, might also affect the behaviors and decisions of current students at U.S. institutions. Amuedo-Dorantes et al. (2019) examine whether the choice of major among already enrolled international students at a U.S. institution responds to the OPT extension policy. They find that after the 2008 OPT extension, the likelihood of current students choosing a STEM major increased. Furthermore, their results suggest varying impacts across fields and program levels.

Particularly, the probability that an enrolled international student will major in an engineering field increases the most. Also, the students who completed their bachelor's degree in a non-STEM field become 1.1 times more likely to pursue a master's degree in a STEM field.

Previous researchers show that the OPT extension policy also influences the stay rate of international students and their transition rate to a work visa in the U.S. (Beine et al. 2023; Demirci 2019). Demirci (2019) hypothesizes that the extension of the duration of the OPT program has many beneficial qualities for international students such as increased payoffs, longer job training periods, and a higher probability of success in H1-B visa applications. He examines whether OPT extension increases the rate of international students who stay and participate in the U.S. labor market via OPT and finds a positive impact, particularly for students at the master's level. The heterogeneity analysis across subgroups of international students in Demirci (2019) also indicates that students from low-income countries are impacted more by the extension of the OPT program. Beine et.al. (2023) and Demirci (2019) also suggest that the likelihood of an international student with a STEM degree transitioning to a work visa has increased.

While countries use visa policies to attract the best and brightest from abroad, the growing foreign student population might also affect labor market outcomes for domestic students. Some studies in the literature provide evidence for such impacts in the labor market. For instance, Demirci (2020) analyzes the effects of labor market integration of international students in the U.S. on the employment status and earnings of native-born individuals. His results indicate that, for students with a master's degree in the same field, an increase in the labor supply of an international student on OPT decreases the employment rates of native-born individuals. In contrast, the increase in labor supply increases the earnings of native-born individuals with higher experience levels.

This paper contributes to the literature by using the Synthetic Control Method (SCM) to construct a synthetic control group that closely matches the characteristics of the treated STEM programs. To the best of our knowledge, we are also the first to work with degree completion data to study the effects of OPT extension policy. The student profile may change between enrollment and graduation due to drop-out rates, transfers, etc. Also, we have a large program-level dataset that highlights the heterogeneity between different programs and allows us to show how the impact of the OPT policy varies based on program characteristics.

# Chapter 3:
# RESEARCH BACKGROUND

## *3.1 Optical Practical Training*

The United States offers three types of student visas: F, M, and J. Before a student can apply for any of these visas, she must get accepted to a Student Exchange and Visitor Program (SEVP) certified U.S. institution of higher education. Nonimmigrant individuals approved to participate in an exchange program receive a J-1 exchange visa.[1] Nonimmigrant individuals approved to participate in non-academic or vocational studies or training receive an M-1 visa. Lastly, nonimmigrant individuals accepted as full-time students in an accredited academic institution in the United States receive an F-1 visa.[2] The vast majority of international students in the United States hold F-1 visas (Demirci, 2019). Moreover, F-1 visas allow international students temporary employment opportunities by applying to the OPT. The employment opportunity must be related to the student's area of study. When approved, the international student will receive work authorization for the specified role for 12 months after their graduation. The student can apply and obtain work permission via OPT, even if she does not have a job offer, but the unemployment spell is limited to 90 days.

The OPT program in the United States is quite appealing to international students and employers compared to other potential employment visas. H-1B visa is used by nonimmigrant individuals who work in specialty occupations that require at least a bachelor's degree or equivalent. There are a set of rules that make it more challenging to acquire an H-1B visa. First, the individual must be employed and sponsored by her employer to pay for the nonrefundable registration/filing fees. Second, U.S. law limits the number of H-1B visas issued. The Immigration Act of 1990 set the annual limit (quota or

[1] The programs include the purpose of teaching, instructing or lecturing, studying, observing, conducting research, consulting, demonstrating special skills, receiving training, or to receive graduate medical education or training. Accessed: May 18, 2024. Retrieved from: https://www.uscis.gov/working-in-the-united-states/students-and-exchange-visitors/exchange-visitors.

[2] The academic institutions include accredited colleges, universities, seminaries, conservatories, academic high schools, elementary schools, or other academic institutions or language training programs. The student must be enrolled in a program or course of study that culminates in a degree, diploma, or certificate and the school must be authorized by the U.S. government to accept international students. Accessed: May 18, 2024. Retrieved from: https://www.uscis.gov/working-in-the-united-states/students-and-exchange-visitors/students-and-employment

cap) to 65,000 nonimmigrant individuals. The employees of institutions of higher education are not part of this quota. The U.S. government issued the H-1B Visa Reform Act of 2004, which extended the quota by 20,000 additional H-1Bs to nonimmigrant individuals with a master's or higher degree from a U.S. institution of higher education. Since the enactment of this act, the number of H-1B registrations has always surpassed the quota limit, either in the first week of the application cycle (the first week of March) or has reached the quota before the end of the current cycle. If the quota is reached in the first week, a random lottery is conducted for the registrations that can continue with their application. For example, in 2024, there were 780,884 registrations with only 188,400 selected for a H-1B visa.[3]

The OPT program grants a 12-month work permit after graduation to any eligible international student with an F-1 visa. Effective April 2008, The Department of Homeland Security (DHS) extended the OPT program's duration by 17 months (from 12 to 29 months) for international students who major in a provided list of STEM fields. Following this extension, in 2011 and 2012, new STEM majors were included in the list of OPT extension-eligible STEM fields. Then, effective May 2016, the DHS published its new rule change, which changed the extension period from 17 months to 24 months (a total of 36 months of OPT STEM extension). The latest update to the STEM field list was in 2022 with an addition of 22 new fields.[4] In this study, we analyze how the OPT extension policy (2008, 2011, and 2012) impacted the number of international students graduating with a STEM major at the bachelor's and master's levels. The archived 2016 version of the DHS STEM Designated Degree Program List can be provided upon request.[5]

[3] H-1B Electronic Registration Process. Accessed: May 20, 2024. Accessed: May 20, 2024. Retrieved from: https://www.uscis.gov/working-in-the-united-states/temporary-workers/h-1b-specialty-occupations-and-fashion-models/h-1b-electronic-registration-process

[4] Update to the Department of Homeland Security STEM Designated Degree Program List. Accessed: May 20, 2024. Retrieved from: https://www.federalregister.gov/documents/2022/01/21/2022-01188/update-to-the-department-of-homeland-security-stem-designated-degree-program-list

[5] Retrieved from: https://www.ice.gov/doclib/sevis/pdf/stemList2016.pdf

### 3.2 *International Students in the United States*

The total number of international students at both undergraduate and graduate levels has increased dramatically in the last two decades (Figure 1), except for the decrease during the COVID-19 pandemic era in 2020. Due to travel restrictions, the switch to online schooling, and the economic downturn in many countries, a fall in the flow of international students is expected. Additionally, the number of international students who use their OPT in the United States has been increasing since the mid-2000s.[6]

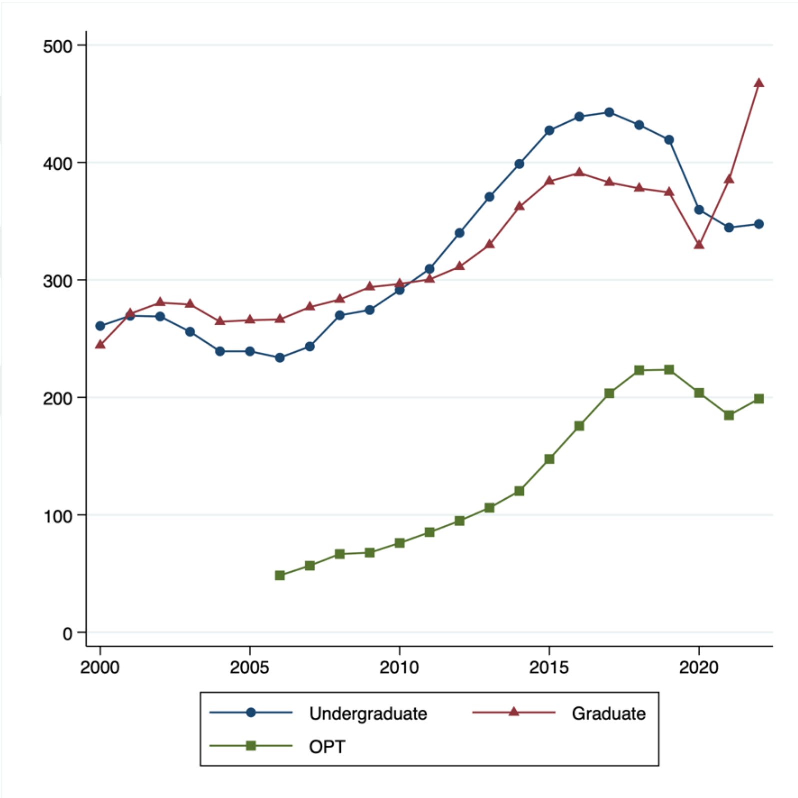


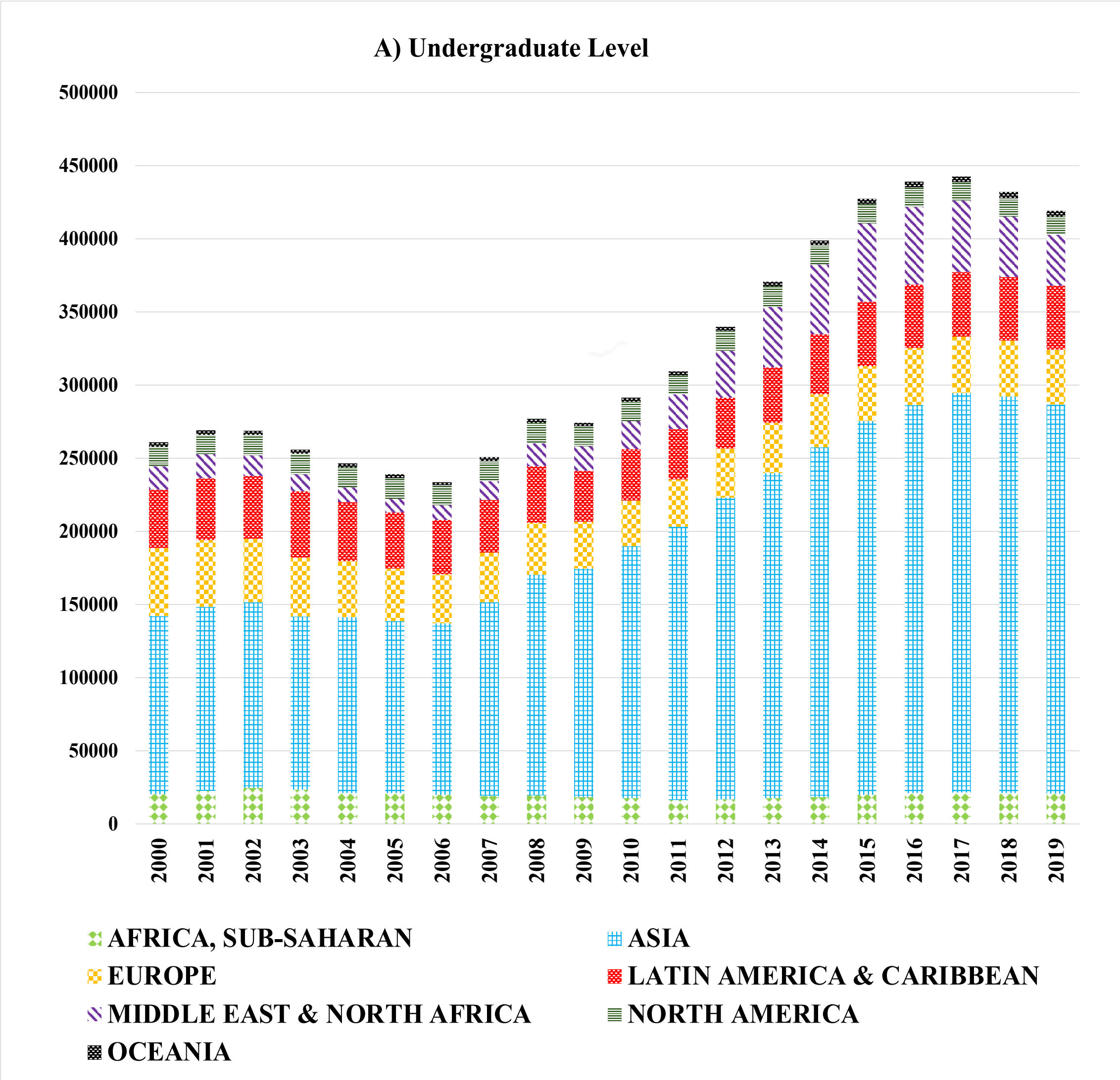

**Figure 1.** The Stock of International Students in the United States

**Notes:** The blue and red lines show the number of international students (denoted in thousands) at undergraduate and graduate levels in the United States. The green line (labeled OPT) demonstrates the number of international students on OPT in the specified year. Source: Institute of International Education. (2023). International Students by Academic Level and Place of Origin, 2000/01-2022/23. Open Doors Report on International Educational Exchange. Retrieved from http://www.opendoorsdata.org.

[6] The Open Doors data only reports OPT numbers starting in year 2006.

Based on Figure 1, the increasing trend in the number of international students, studying in the United States, started in 2005, suggesting an upward trend in foreign graduation independent of the OPT extension policy. This trend may be a response to the economic, political, and social changes happening in the countries of origin of international students. For example, the expansion of the Chinese economy and fellowship programs sponsored by the Saudi government, among others, can contribute to the observed trend.

Figure 2 shows the flow of international students from different continents studying in the United States from 2000 to 2019. There is an upward trend in the number of international students for each continent at each level. Particularly, Asia and the Middle East experience the highest growth at both levels. The largest body of international students comes from Asia at the bachelor's and master's levels. After forming an idea of the general continent-level trend, we focus on country-specific trends for a more detailed picture. Table 1 demonstrates the top ten origin countries with the largest changes in the number of international students from 2000 to 2019. At the undergraduate level, the largest changes are observed in China with 140,846 students (the difference between 148,880 students in 2018 and 8,034 students in 2003), Saudi Arabia with 32,264 students (the difference between 33,952 students in 2015 and 1,688 in 2005), and Japan with 23,452 (the difference between 32,136 students in 2000 and 8,684 in 2019) students. At the graduate level, the largest changes are observed in China with an 89,479-student increase between 2005 (47,167 students) and 2009 (137,096 students), India with 65,102 students between 2000 (39,797 students) and 2016 (104,899 students), and Saudi Arabia with 12,195 students between 2005 (1,015 students) and 2015 (13,210 students).


A) Undergraduate Level
500000
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
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2011
2012
2013
2014
2015
2016
2017
2018
2019
AFRICA, SUB-SAHARAN
ASIA
EUROPE
LATIN AMERICA & CARIBBEAN
MIDDLE EAST & NORTH AFRICA
NORTH AMERICA
OCEANIA

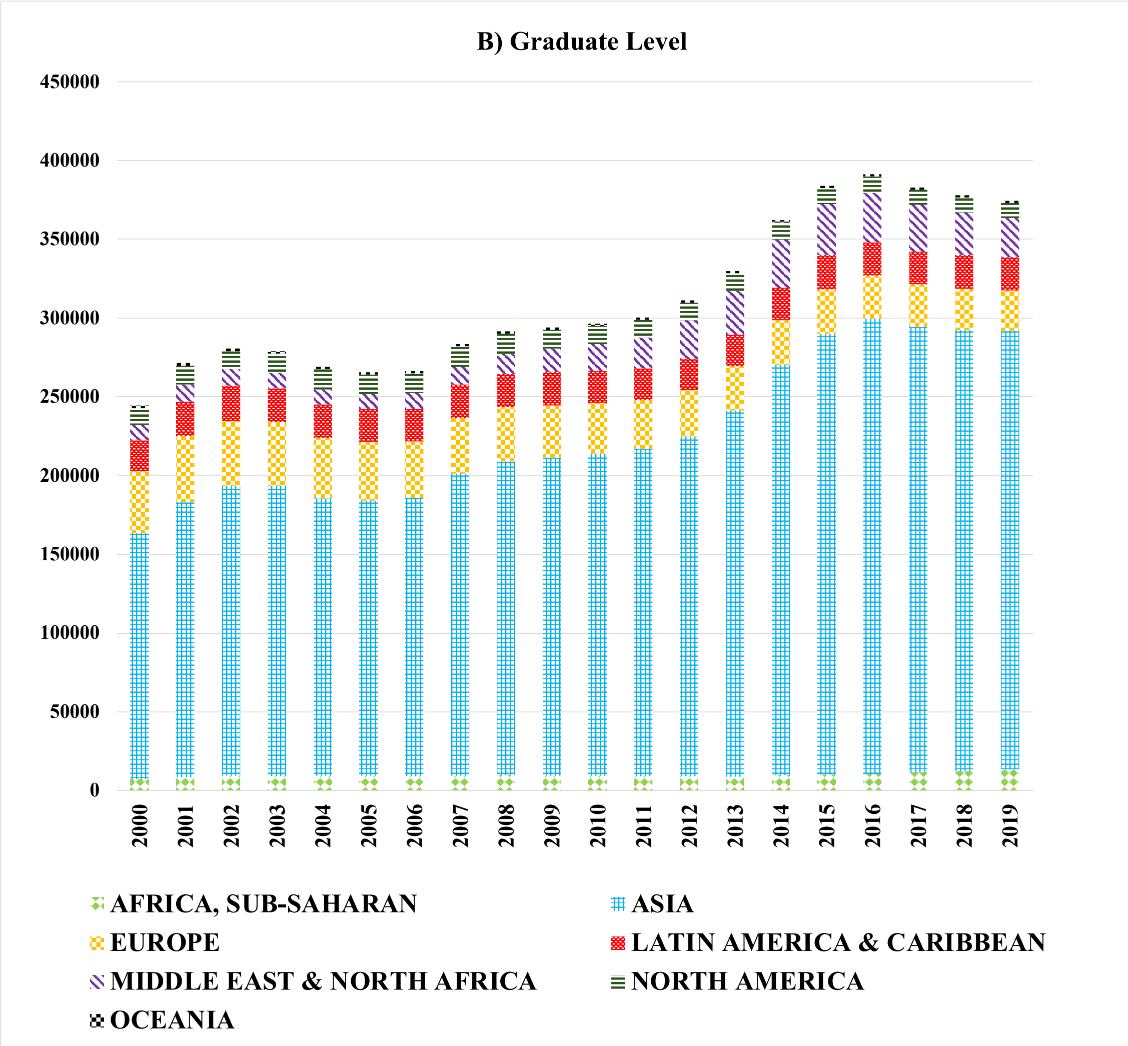



**Figure 2.** The Number of International Students from Different Continents from 2000 to 2019

**Notes:** The figures demonstrate the number of international students at the undergraduate and graduate levels from 7 different continents. Source: Institute of International Education. (2023). "International Students by Place of Origin and Academic Level, 2000/01 - 2022/23" Open Doors Report on International Educational Exchange. Retrieved from https://opendoorsdata.org/.

**Table 1. Origin Countries with the Largest Changes in the Number of International Students from 2000 to 2019**

| Country | Change | Max | Year | Min | Year |
|---|---|---|---|---|---|
| **Panel A: Undergraduate Level** | | | | | |
| China | 140,846 | 148,880 | 2018 | 8,034 | 2003 |
| Saudi Arabia | 32,264 | 33,952 | 2015 | 1,688 | 2005 |
| Japan | 23,452 | 32,136 | 2000 | 8,684 | 2019 |
| South Korea | 19,451 | 38,232 | 2011 | 18,781 | 2000 |
| Vietnam | 15,627 | 17,048 | 2018 | 1,421 | 2000 |
| India | 12,773 | 25,032 | 2019 | 12,259 | 2000 |
| Kuwait | 6,821 | 7,871 | 2017 | 1,050 | 2006 |
| Nepal | 6,002 | 7,894 | 2008 | 1,892 | 2000 |
| Brazil | 4,852 | 8,372 | 2019 | 3,520 | 2006 |
| Taiwan | 4,782 | 10,688 | 2000 | 5,886 | 2013 |
| **Panel B: Graduate Level** | | | | | |
| China | 89,479 | 137,096 | 2019 | 47,167 | 2005 |
| India | 65,102 | 104,899 | 2016 | 39,797 | 2000 |
| Saudi Arabia | 12,195 | 13,210 | 2015 | 1,015 | 2005 |
| South Korea | 10,244 | 25,463 | 2008 | 15,219 | 2019 |
| Iran | 8,672 | 9,695 | 2017 | 1,023 | 2000 |
| Taiwan | 7,731 | 16,679 | 2006 | 8,948 | 2016 |
| Japan | 6,917 | 9,691 | 2001 | 2,774 | 2019 |
| Thailand | 5,553 | 7,672 | 2001 | 2,119 | 2019 |
| Bangladesh | 4,564 | 5,787 | 2019 | 1,223 | 2006 |
| Nigeria | 4,544 | 5,565 | 2019 | 1,021 | 2000 |

**Notes:** Panel A and Panel B report the country of origin for the international students studying in the United States in a ranked order at the spesified academic levels. Ranking is performed from largest to the lowest. Max and year columns denote the maximum number of students observed for the specified origin country, in the specified year. Min and year columns denote the minimum number of students observed for the specified origin country, in the specified year. Lastly, the change columns report the largest observed for each country, calculated as the difference between the maximum and the minimum observed number. Source: Institute of International Education. (2023). International Students by Academic Level and Place of Origin, 2000/01-2022/23. Open Doors Report on International Educational Exchange. Retrieved from http://www.opendoorsdata.org

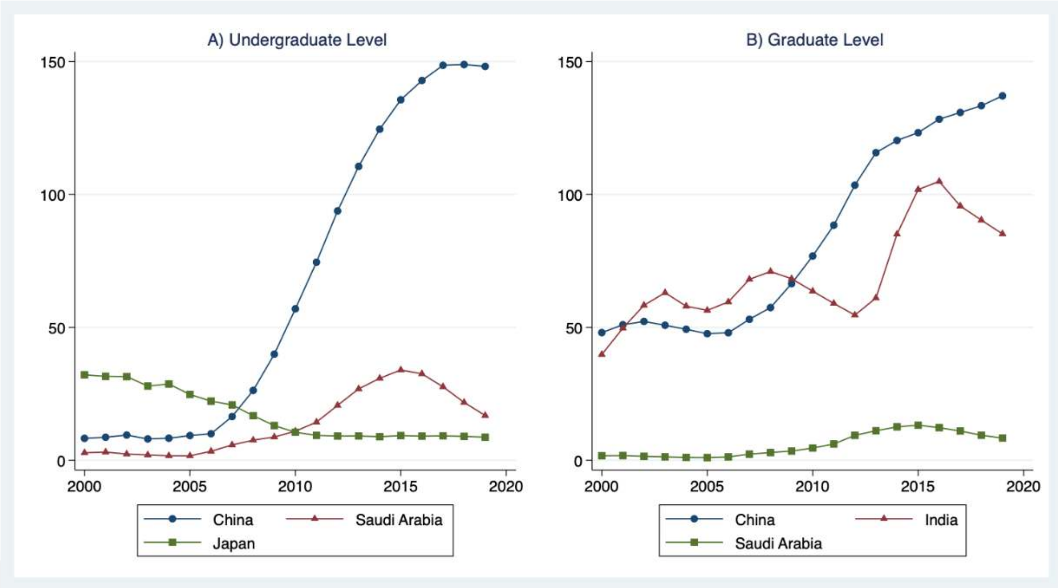



**Figure 3.** The Flow of International Students to the United States from Specified Countries

**Notes:** Each figure shows the number of international students originating from the stated country and studying in the United States. The top 3 countries of origin at the undergraduate level are China, Saudi Arabia, and Japan. The top 3 countries of origin at the graduate level are China, India, and Saudi Arabia. Source: Institute of International Education. (2023). International Students by Academic Level and Place of Origin, 2000/01-2022/23. Open Doors Report on International Educational Exchange. Retrieved from http://www.opendoorsdata.org.

Figure 3 illustrates the trends in the flow of international students studying in the U.S., focusing on the top three countries at the undergraduate and graduate levels. There is an increasing trend in China and Saudi Arabia at both levels, which can be attributed to the expansion of the Chinese economy and the fellowship programs sponsored by the Saudi government. There is also an upward trend in the number of international students from India, predominantly starting in the mid-2000s, potentially stemming from the rapid economic growth in India, especially in industries such as information technology, engineering, and pharmaceuticals. In contrast, Japanese students experience a downward trend at the undergraduate level which might result from the economic downturn in Japan in the early 2000s caused by the bursting of the Japanese asset price bubble.

**Table 2. Origin Countries with the Largest Changes in the Number of Students on OPT from 2006 to 2019**

| Country | Change | Max | Year | Min | Year |
|---|---|---|---|---|---|
| India | 73,927 | 84,630 | 2018 | 10,703 | 2006 |
| China | 64,209 | 71,380 | 2019 | 7,171 | 2006 |
| South Korea | 3,577 | 8,074 | 2018 | 4,497 | 2006 |
| Vietnam | 2,519 | 2,718 | 2019 | 199 | 2006 |
| Taiwan | 2,514 | 5,507 | 2019 | 2,993 | 2006 |
| Nigeria | 2,145 | 2,583 | 2019 | 438 | 2007 |
| Iran | 2,094 | 2,269 | 2018 | 175 | 2007 |
| Canada | 1,940 | 3,593 | 2018 | 1,653 | 2006 |
| Saudi Arabia | 1,927 | 2,003 | 2018 | 76 | 2006 |
| Nepal | 1,805 | 2,232 | 2019 | 427 | 2006 |

**Notes:** The table reports the largest changes in the number of students who were on OPT from the year 2006 to 2019. OPT data became available starting in the year 2006. The list reports the top 10 largest changes, and the ranking is performed from the largest to the lowest. Max and year columns denote the maximum number of students observed for the specified origin country, in the specified year. Min and year columns denote the minimum number of students observed for the specified origin country, in the specified year. Lastly, the change columns report the largest observed for each country, calculated as the difference between the maximum and the minimum observed number. Source: Institute of International Education. (2023). International Students by Academic Level and Place of Origin, 2000/01-2022/23. Open Doors Report on International Educational Exchange. Retrieved from http://www.opendoorsdata.org

Overall, the upward trend in the number of incoming international students is driven by China, Saudi Arabia, and India. Next, we question how the diversity of the international students who use OPT has changed. Table 2 exhibits the top ten origin countries with the largest changes in the number of international students who have OPT from 2006 to 2019. The list and the order of the top 10 origin countries have changed. The largest changes in the number of international students who have OPT are now observed in India with 73,92 students (the difference between 84,630 students in 2018 and 10,703 students in 2006), China with 64,209 students (the difference between 71,380 students in 2019 and 7,171 students in 2006), and South Korea with 3,577students (the difference between 8,074 students in 2018 and 4,497 students in 2006). Despite the largest increase in the number of incoming students observed for Chinese students, Indian students are the largest group in the OPT take-up statistics. Moreover, the increase in the number of Saudi students on OPT is quite limited. All these suggest that some patterns observed in the number of incoming international students are driven by origin-specific factors, regardless of the OPT extension for STEM programs in the United States.

**Table 3. Field of Study Choice by Country of Origin, SEVIS Data**

| | All | China | Saudi Arabia | India | Japan |
|---|---|---|---|---|---|
| **Panel A: Bachelor's Level** | | | | | |
| Engineering | 0.078 | 0.060 | 0.191 | 0.146 | 0.024 |
| Computer Science | 0.091 | 0.083 | 0.309 | 0.212 | 0.030 |
| Natural Sciences | 0.073 | 0.052 | 0.028 | 0.083 | 0.060 |
| Mathematics | 0.015 | 0.047 | 0.004 | 0.014 | 0.010 |
| Other Science and Engineering | 0.026 | 0.020 | 0.039 | 0.030 | 0.025 |
| Business and Economics | 0.351 | 0.527 | 0.300 | 0.323 | 0.293 |
| Other Fields | 0.366 | 0.211 | 0.130 | 0.194 | 0.558 |
| **Panel B: Master's Level** | | | | | |
| Engineering | 0.120 | 0.107 | 0.145 | 0.188 | 0.038 |
| Computer Science | 0.220 | 0.154 | 0.177 | 0.448 | 0.041 |
| Natural Sciences | 0.039 | 0.059 | 0.034 | 0.046 | 0.027 |
| Mathematics | 0.018 | 0.063 | 0.009 | 0.009 | 0.011 |
| Other Science and Engineering | 0.031 | 0.041 | 0.033 | 0.031 | 0.026 |
| Business and Economics | 0.284 | 0.352 | 0.332 | 0.172 | 0.287 |
| Other Fields | 0.288 | 0.224 | 0.269 | 0.106 | 0.571 |

**Notes:** Each column in each panel shows the field distribution of international students from the specified origin. The sample is restricted to F-1 visa holders whose program start date is between January 1, 2004, and April 2, 2008, which is a period before the OPT STEM extension policy.

Source: F-1 visa data from the Student and Exchange Visitor Information System (SEVIS).

The Open Doors data show a discernible upward trajectory in the number of international students in the last two decades. There is great heterogeneity respecting the students' countries of origin. Naturally, another question comes to mind: what else is driving this heterogeneity? Table 3 presents the field of study preferences of international students. We focus on 4 of the top origin countries to observe the field distribution of international students from the specified origin. At both levels, out of all international students, the two fields with the highest percentages are the other categories (37% of the students at the bachelor's level and 29% of the students at the master's level), and business and economics (35% of the students at the bachelor's level and 28% of the students at the master's level). At the bachelor's level, the highest percentages are observed for business and economics for Chinese students (53%) and Indian students (32%), computer science (31%) for Saudi Arabian students, and other fields category (56%) for Japanese students. The most popular STEM field at both levels is Computer Science, except for Japanese students at the bachelor's level, for whom Natural Sciences is the most popular STEM field. Similarly, at the master's level, the highest percentages are observed for business and economics for Chinese students (35%) and Saudi Arabian students (33%), computer science (45%) for Indian students, and other fields category (57%) for Japanese students. We can conclude that the field distribution varies based on countries of origin. Overall, 28% and 40 % of the international students study a STEM field, at the bachelor's and master's levels, respectively. However, the likelihood of majoring in STEM fields for students, from origin countries with a pre-existing trend in enrollment before the OPT extension, differs from these averages. Thus, if these students keep their major preferences over time, the graduation statistics from STEM programs would differ, which constitutes a confounding factor in identifying the impact of the OPT extension policy.

# Chapter 4:
# DATA

This section introduces the data used in the empirical analysis of this thesis. Mainly four types of data constitute the basis of the analysis: i) student graduation data (which provides the dependent variable of interest), ii) foreign student visa data (which are used to create predictor variables in matching), iii) data indicating labor market conditions (which are used as control variables in regression analysis), and iv) other regional or university-specific data (which are used in the heterogeneity analysis). I describe each source in detail below.

## *4.1 IPEDS Student Data*

The U.S. Department of Education's National Center for Education Statistics (NCES) collects data on postsecondary institutions located in the United States. This data system also known as the Integrated Postsecondary Education Data System (IPEDS), combines data from all postsecondary institutions that either participate in or are applicants of any federal student financial aid programs. Currently, IPEDS collects survey data in three collection periods (fall, winter, and spring) in 12 major surveys: Fall data collection includes Institutional Characteristics, 12-month Enrollment, and Completions. Winter data collection includes Admissions, Graduation Rates, 200 Percent Graduation Rates, Outcome Measures, and Student Financial Aid. Spring data collection includes Academic Libraries, Fall Enrollment, Human Resources, and Finance. Each survey has multiple versions where differences can be observed in the number, reporting, and type of variables available. In this study, we obtain the Institutional Characteristics and the Completions Survey data from IPEDS.[7]

The Completions Survey collects data on the number of graduates from each institution by 6-digit CIP (Classification of Instructional Programs) code, award level, race/ethnicity, and gender. The Institutional Characteristics Survey collects data on

[7] There are 5 different subcategories to the Completions Survey data. We use the survey titled, "Awards/degrees conferred by program (6-digit CIP code), award level, race/ethnicity, and gender: July 1, 2021 to June 30, 2022". There are 6 different subcategories to the Institutional Characteristics Survey data. We use the survey titled, "Directory Information". Further details in subcategories can be found at: https://nces.ed.gov/ipeds/datacenter/DataFiles.aspx?goToReportId=7&sid=d8c1a7cc-ee25-4fb7-886b-7175d0e920ec&rtid=7

directory information, educational offerings, organization and accreditation, and admissions. We restrict our analysis to the period from 1995 until 2019 for the following two reasons. First, the Completions Survey version we use started collecting race/ethnicity data in 1995. Second, we want to avoid any complications that might arise in our data/analysis due to COVID-19 which started in March 2020.

The Completions Survey data provides the number of degrees granted from each academic program by the demographic characteristics of students. Each program is defined at the university and has a 6-digit CIP code, i.e., economics at the master's level at Pomona College. Broadly, students are grouped into two categories: domestic vs. foreign. The gender and race/ethnicity variables are collected separately and denote the total number of men and women observed in each category. We group race/ethnicity into six categories for domestic students: i) non-Hispanic black or African American, ii) non-Hispanic white, iii) Hispanic or Latino, iv) Asian or Pacific Islander, v) American Indian/Alaskan Native, and vi) others. Additionally, we have non-resident alien data which refers to international students.

There are three important changes observed in the collection of Completions Survey data, which might raise the issue of over-time consistency in statistics for our study. First, as of the 2010-11 Fall data collection, IPEDS switched to a new post-baccalaureate award levels system. The award levels 9 (doctor's degree), 10 (first-professional degree), and 11 (first professional certificate) were no longer in use. We perform our analysis at bachelor's and master's levels which corresponded to the award levels 5 and 7, respectively. After the change in the award levels system, some of the CIP codes with the old award level 10, were reassigned as award level 7 (master's degree) and some as 17 (doctor's degree-research/scholarship), 18 (doctor's degree-professional practice), or 19 (doctor's degree-other). To fix the inconsistency issue, we checked the CIP codes, with award level 10, for the period starting from 1995 until 2009. We identified the previously mentioned CIP codes and checked what their new award level became in the year 2010. Then, depending on their new award level, we reassigned them to master's or doctor's levels, accordingly. This method presented two issues. In some cases, the CIP code was associated with both master's and doctor's degree levels. In these scenarios, we reassigned the CIP code to the award level with the higher number of observations. For example, in 2010, the CIP code 140701 (Chemical Engineering) was observed as 142 master's degrees, 107 as doctor's degrees-research/scholarship, and 1 observation as doctor's degree-other. We reassigned the CIP code 140701 (Chemical Engineering)'s award level as a master's degree since it had a higher number of observations. In contrast, in some cases, the CIP code had the same number of observations at both award levels in 2010. For those cases, we referred to the previous year and checked the number of observations for the CIP code at different award levels. We preceded this process until we reached an inequality between the number of observations of master's and doctor's levels. Then, we reassigned the CIP code to the award level with the highest number of observations. For example, the CIP code 151102 (Surveying) was observed as 1 master's degree and 1 doctor's degree-research/scholarship in 2010. Then, we referred to the year 2009 and again, observed 1 master's degree and 1 doctor's degree-research/scholarship. Finally, we referred to the year 2008 and observed 2 master's degrees and 1 doctor's degree-research/scholarship. We reassigned the award level of the CIP code 151102 (Surveying) as a Master's degree.

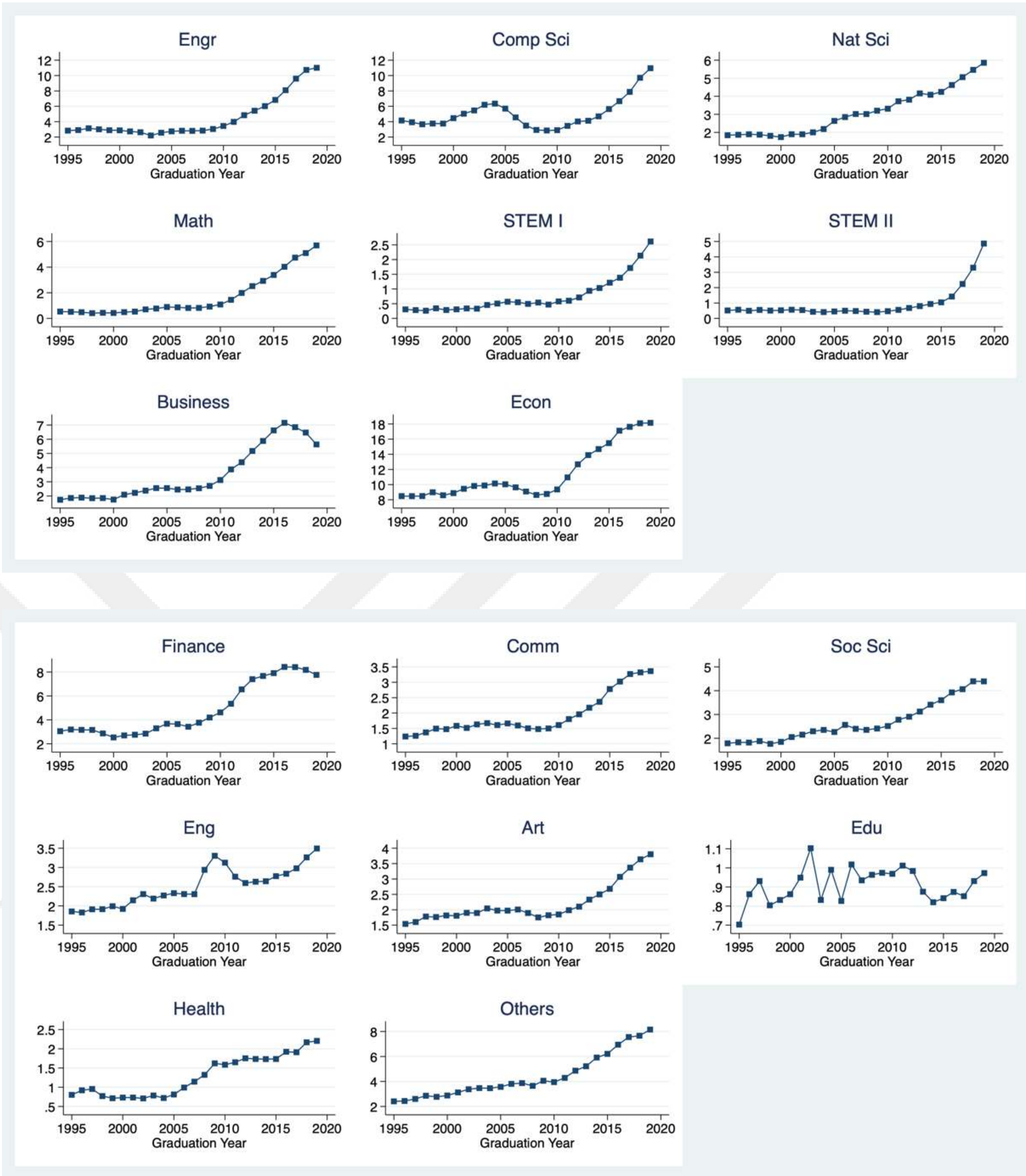
Second, the reporting method of race categories has changed over time. From 1995 to 2007, race variables for Asian and Other Pacific Islander students were defined together as a single variable. Starting in 2008, the mentioned race variable was separated into two new variables: Asian, and Native Hawaiian/Pacific Islander. To achieve consistency, we integrated the two categories into a consolidated variable for years after 2008. In other words, the Asian race category in our analysis also includes the Native Hawaiian/Pacific Islanders race category.

Third, the field classification was inconsistent over time. The NCES provides the CIP codes to track fields of study for all students at any award level in the postsecondary institutions in the United States. The framework was developed in 1980 with follow-up revisions in 1985, 1990, 2000, 2010, and 2020. In this study, our period of analysis refers to 1990, 2000, and 2010 CIP code versions.

The NCES provides two crosswalks, one shows changes from 1990 to 2000 and the other from 2000 to 2010. We use the crosswalks to manually update all CIP codes to 2010 versions. There were four possible actions taken in the crosswalks: deleting a code, reporting a field under a different code (moving), creating a new code, and leaving the code as it is (no substantial changes). Most of the fields remained the same (1452 CIP codes in 2000 and 1685 CIP codes in 2010. For fields under the "moved" category (286 CIP codes in 2000 and 116 CIP codes in 2010), we directly apply the provided crosswalk. The fields under the "new" category (574 CIP codes in 2000 and 354 CIP codes in 2010) were kept as reported. There was inconsistency for the 77 CIP codes that were deleted in the 2000 update, and the 47 CIP codes in the 2010 update. For some of the deleted CIP codes, the crosswalk provides a “report under” option. For example, in 2000, CIP code 30102 (Environmental Science/Studies) was deleted, however, the crosswalk indicates it to be reported under CIP code 30103 (Environmental Studies) or 30104 (Environmental Science). Unfortunately, this option did not exist for 25 CIP codes in 2000 and 32 CIP codes in 2010. We fixed this problem by manually finding the closest match to deleted CIP code’s title, from the remaining CIP codes. For example, in 2010, CIP code 2308 (English Literature (British and Commonwealth)) was deleted. We matched this with CIP code 2314 (Literature) to obtain consistency in our sample.

Following this, we created a dummy variable called “eligibility” which shows when a field of study becomes eligible for OPT policy. There are four levels to this variable: zero if ineligible (non-STEM), one if the field becomes OPT-eligible in 2008, two if the field becomes OPT-eligible in 2011, and three if the field becomes OPT-eligible in 2012. Then based on eligibility status and field similarities, we aggregate the 6-digit CIP codes into 16 fields. These are Engineering, Computer Science, Natural Sciences, Mathematics, Science and Engineering I (STEM fields that became eligible in 2011), Science and Engineering II (STEM fields that became eligible in 2012), Economics, Business, Finance, Communications, Social Sciences, English, Art, Education, Health, and Others.

Figure 4, Panel A demonstrates the number of foreign-born students majoring in the specified aggregate fields at the bachelor’s level. All fields show an increasing trend in the number of international students. Economics is the most popular field, followed closely by Engineering and Computer Science. Even though there is an increasing trend in non-STEM fields, the total number of students is not as high compared to the STEM fields (except for Business, Economics, and Finance). Right around 2010, we see a significant increase in the graduating number of international students in all fields.




**Panel A.** Bachelor's Level

**Notes:** This figure shows the number of international students (in thousands - denoted on the y-axis) majoring in the specified field at the bachelor's level in the United States. The aggregate fields are Engineering, Computer Science, Natural Sciences, Mathematics, Science and Engineering I, Science and Engineering II, Business, Economics, Finance, Communications, Social Sciences, English, Art, Education, Health, and Others.

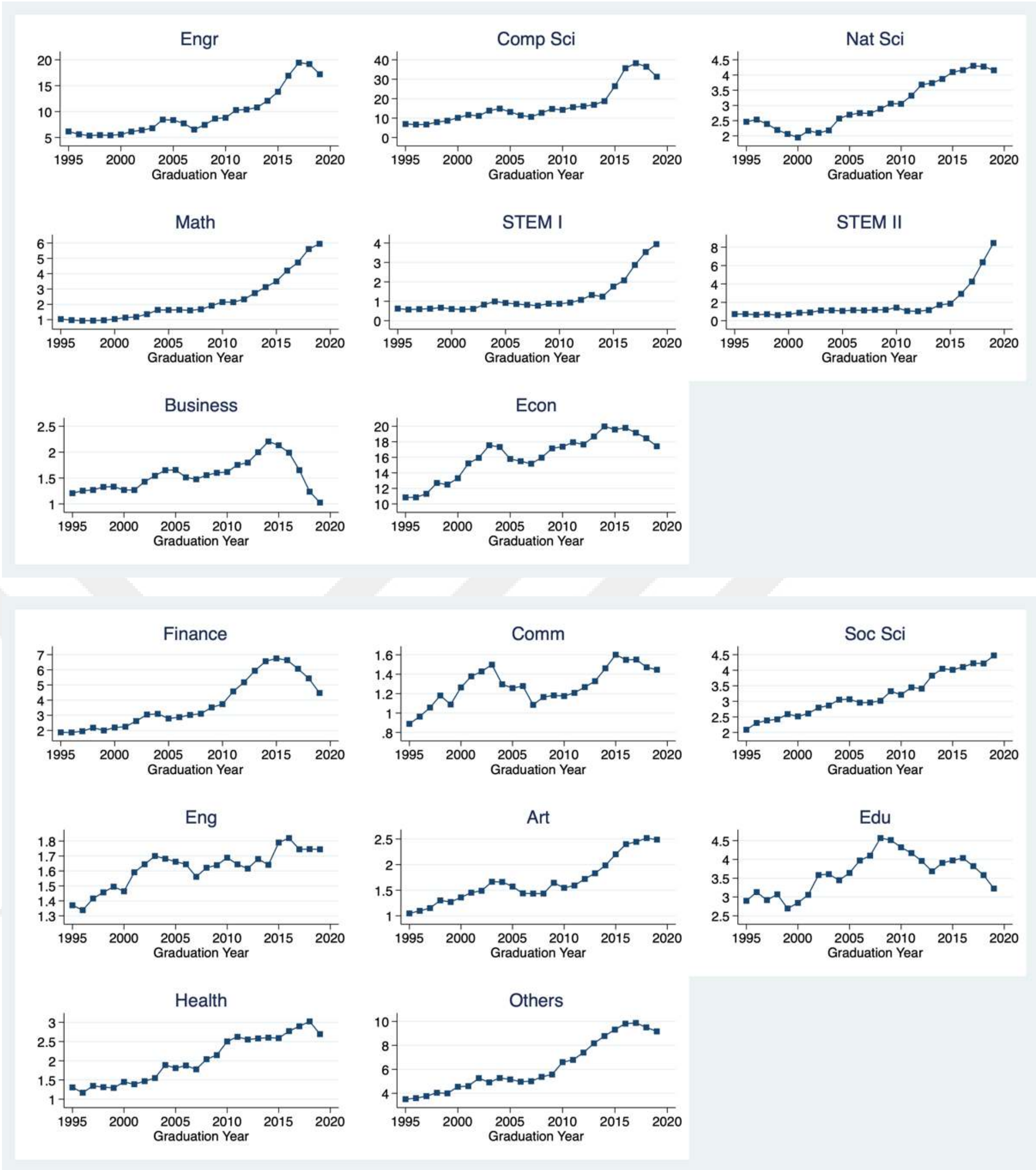



**Figure 4.** Total Number of Foreign-Born Students in Each Aggregate Field

**Panel B.** Master's Level

**Notes:** This figure shows the number of international students (in thousands - denoted on the y-axis) majoring in the specified field at the master's level in the United States. The aggregate fields are Engineering, Computer Science, Natural Sciences, Mathematics, Science and Engineering I, Science and Engineering II, Business, Economics, Finance, Communications, Social Sciences, English, Art, Education, Health, and Others.

Similarly, Figure 4, Panel B demonstrates the number of foreign-born students majoring in the specified aggregate fields at the master's level. We observe more fluctuations in the number of foreign students majoring in different fields. In all STEM fields (except Science and Engineering I and II), we note an increasing trend before the graduation year 2010 (also before the hypothesized OPT-extension policy). This is one of the initial observations that drives us to hypothesize that the increasing number of graduating foreign students might not be solely attributed to the OPT policy change. Computer Science is the most popular field, followed closely by Engineering and Economics. The total number of students in non-STEM fields is still not as high compared to the STEM fields (except for Economics). However, they are higher compared to the number of graduating foreign students at the bachelor's level in the same non-STEM fields.

## 4.2 Sample Restrictions

Institutional characteristics survey data consists of directory information of institutions registered in the IPEDS dataset in the specified year. The variables of interest are UNITID (unique identification number of the institution), INSTNM (institution/entity name), CONTROL (whether an institution is operated by publicly elected or appointed officials or by privately elected or appointed officials and derives its major source of funds from private sources), FIPS (state code), and CARNEGIE (classification used to group institutions based on their degree-granting activities).

The Carnegie Classification was created in 1970 by the Carnegie Foundation partnered with the American Council on Education, and has been updated in 1976, 1987, 1994, 2000, 2005, 2010, 2015, 2018, and 2021. The system includes all degree-granting institutions located in the United States that are represented in the IPEDS data system. Our sample uses the 1994 version of the Carnegie Classification which classifies institutions into 19 different categories: Research Universities I, Research Universities II, Doctoral Universities I, Doctoral Universities II, Masters Comprehensive I, Masters Comprehensive II, BA Liberal Arts Colleges I, Baccalaureate Colleges II, Associate of Arts Colleges, Theological Seminaries, Medical Schools, Other Health Profession Schools, Schools of Engineering and Technology, Schools of Business and Management, Schools of Art, Music, and Design, Schools of Law, Teachers Colleges, Other Specialized Institutions, Tribal Colleges, and No Response/Missing. The CONTROL variable groups institutions into 4 categories: Public, Private Non-Profit, Private For-Profit, and No response/Missing.

Our sample only includes institutions with consistent data coverage. For example, if an institution's data is missing for a year or if a school closes after a certain year etc., we drop such institutions from our sample. We also drop some of the consistent institutions in the raw data if they do not report any student data. We also exclude the following institution types: Public Associate of Arts Institutions, Private Associate of Arts Institutions, Private For-Profit Institutions, Specialized Institutions[8], and institutions with missing data. We also exclude institutions located in the following U.S. territory areas: American Samoa, Federated States of Micronesia, Guam, Marshall Islands, Northern Marianas, Palau, Puerto Rico, and the Virgin Islands. Lastly, we exclude the four schools in the sample that mainly depend on online degree programs.[9]

For each institution, we also define academic programs and impose some sample further restrictions. The sample of analyzed programs consists only of those programs that had at least one student graduated during the pre-treatment era (from 1995 to 2008, both included). The programs are classified as combinations of institution, level of education, and aggregate fields. Thus, each program consists of multiple 6-digit CIP codes. We aim to estimate the effect of the OPT extension on the programs that existed before the policy.

We use the Carnegie Classification of Institutions of Higher Education and the control variable in the survey data to group our institutions into two categories: Research vs. non-research, and Public vs. Private. In our sample, Doctoral Institutions (including Research Universities II, Doctoral Universities I, Doctoral Universities II), Research I Institutions, and Liberal Arts I Institutions are classified as research institutions. The rest of the institutions are classified as non-research. We categorize institutions as either public or private based on the label assigned to their CONTROL variable.

Table 4 reports the total number of institutions and the distribution of foreign-born students in the sample, at the specified level. In our sample, we have 493 and 475 public institutions, at the bachelor's and master's levels, respectively. The number of private institutions at both bachelor's and master's levels is twice as much (803 and 693, respectively). Similarly, the number of research institutions is 391 and 324, in contrast,

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[8] The specialized institutions are Theological Seminaries, Medical Schools, Other Health Profession Schools, Schools of Engineering and Technology, Schools of Business and Management, Schools of Art, Music, and Design, Schools of Law, Teachers Colleges, Other Specialized Institutions, and Tribal Colleges.

[9] These schools are Thomas Edison State College, Regents College (Excelsior's University), Charter Oak State College, SUNY Empire State College.

non-research institutions are almost thrice as much, at 905, and 844, at the bachelor's and master's levels, respectively. At the bachelor's level, foreign-born students are highly concentrated at public and research institutions, at 63% and 62.96%, respectively. In contrast, at the master's level, foreign-born students are almost evenly concentrated at public institutions, at 54.91%, however, highly concentrated at research institutions, at 77.27%.

**Table 4. Summary Statistics of Institutions**

| | Panel A: Bachelor's | | Panel B: Master's | |
|---|---|---|---|---|
| Institution Type | Instituions | Distribution | Instituions | Distribution |
| Research I - Public | 59 | 25.21% | 59 | 25.47% |
| Research I - Private | 28 | 9.38% | 29 | 22.16% |
| Liberal Arts I - Public | 6 | 0.09% | 4 | 0.00% |
| Liberal Arts I - Private | 156 | 5.36% | 88 | 0.45% |
| Doctoral - Public | 91 | 14.91% | 91 | 17.15% |
| Doctoral - Private | 51 | 8.01% | 53 | 12.03% |
| Other - Public | 337 | 22.79% | 321 | 12.28% |
| Other - Private | 568 | 14.25% | 523 | 10.45% |
| Public | 493 | 63.00% | 475 | 54.91% |
| Private | 803 | 37.00% | 693 | 45.09% |
| Research | 391 | 62.96% | 324 | 77.27% |
| Non-Research | 905 | 37.04% | 844 | 22.73% |

Notes: This table demonstrates the number of instituions and the distribution of postsecondary level foreign-born students in our sample, at specified award levels. The instituion types are classfied by the Carnegie Classification of Institutions of Higher Education in the United States Non-Research institutions are the total of the categories "Others-Public" and "Others-Private". Research institutions are the total of the following instituion types: Research I, Liberal Arts I, and Doctoral. The second and fourth columns indicate the number of institutions. The third and fifth columsn state the distribution of the international students in the specified level in the United States. Panel A and Panel B report the summary statistics at the bachelor' and master's levels, respectively.

At a more specific level, we observe that at the bachelor's level, the distribution of foreign-born students is highest at public research I institutions (25.21%), followed by other public institutions (22.79%), and public doctoral institutions (14.91%). At the master's level, the foreign-born students are distributed highest at public research I institutions (25.47%), followed by private research I institutions (22.16%), and public doctoral institutions (17.15%).

### *4.3 SEVIS Student Data*

The Student Exchange and Visitor Program (SEVP), a part of the U.S. Department of Homeland Security (DHS), provides data from nonimmigrant students and exchange visitors to various government agencies. Alongside administering the web-based data collection service called the Student and Exchange Visitor Information System (SEVIS), the SEVP also conducts approvals for institutions of higher education that can admit nonimmigrant students and oversees requirements for institutions and students to maintain their visa status. In this thesis, we use data from SEVIS records obtained via a Freedom of Information Act request. Our data show schooling information of foreign students along with their basic demographic characteristics. An earlier version of such data for foreign students completing their F-1 visa status between 2004 and 2013 is used by Demirci (2019) and Demirci (2020). This thesis uses a newer version covering individual records of F-1 visa recipients who started their education between 2004 and 2015, which is used by Bound et al. (2020).

One-to-one matching of SEVIS data with IPEDS completion data is feasible as the field code of the enrolled program at the 6-digit CIP level and the school's name is available in SEVIS data. Thus, we first collapse the individual-level SEVIS records to the program-level data and match it with IPEDS student data. Unlike the IPEDS data, SEVIS provides information about the country of origin. This information allows us to construct some unique program-specific variables to be used as predictors in matching. Particularly, we use the relative dependency of each program on specific origins in the pre-OPT period. We define these variables as follows. Let $s_{iF}$ denote the share of F-1 visa recipients enrolled in program $i$ and $s_{io}$ denote the share of F-1 visa recipients from origin country $o$ and enrolled in program $i$. We define the relative share for each country as $r_{io} = \frac{s_{io}}{s_{iF}}$. If the number of students coming from origin $o$ changes over time, programs with larger dependency on this origin in foreign enrollment are expected to be affected more because of the network effect. The variable $r_{io}$ captures such a relationship. In practice, we construct these relative share variables for students enrolling before April 2008, the month the OPT extension policy was announced.

### 4.4 *Data for Labor Market Conditions*

To construct field-specific control variables for labor demand conditions, we use the relevant data. The U.S. Bureau of Labor Statistics provides the Occupational Employment and Wage Statistics (OEWS) program that estimates employment and wage statistics based on survey data of business establishments.[10] The OEWS classifies jobs into different occupations based on assigned job duties, also known as the Standard Occupational Classification (SOC) system. In this thesis, we use the occupation-specific employment and wage data from the OESW program.

The reporting method of SOC codes started in 1977, with subsequent revisions and implementations in 1980, 2000, 2010, and 2018. The SOC system has been widely used in other federal data resources after its major revision in 2000. The SOC system uses a hierarchal tiered system to organize occupations into four levels: major occupation groups, minor occupation groups, broad occupations, and detailed occupations.

The 6-digit SOC code's first two digits denote the major occupation group; for example, 190000 is the major occupation code for Life, Physical, and Social Science Occupations. The third digit denotes the minor occupation group; for example, 191000 is the minor occupation code for Life Scientists. The fourth and fifth digits denote the broad occupation, 191010 is the broad occupation SOC code for Agricultural and Food Scientists. Finally, the sixth digit denotes the detailed occupation; 191011 (Animal Scientists), 191012 (Food Scientists and Technologists), and 191013 (Soil and Plant Scientists) are the detailed occupations under the broad category.

The NCES provides a crosswalk that matches 6-digit CIP 2010 codes to 6-digit SOC 2010 codes. The purpose of this crosswalk is to identify the most related occupations for each field of study. One CIP code might be matched with multiple SOC codes. We use this crosswalk to calculate field-specific labor demand conditions. However, there are 203 CIP codes present in the crosswalk with a "NO MATCH" comment. For those fields, we refer to the nearest broader tier's CIP code they are reported under and its matched SOC codes. For example, for CIP code 10508 (taxidermy/taxidermist), there was no

[10] "The OEWS survey covers wage and salary workers in nonfarm establishments and does not include the self-employed, owners and partners in unincorporated firms, household workers, or unpaid family workers." Information retrieved from: https://www.bls.gov/oes/oes_emp.htm

match. Thus, we refer to the nearest broader CIP code which would be 10500 (Agricultural and Domestic Animal Services). However, this code does not exist in the crosswalk either. So, we move one step broader, to the CIP code 10000 (Agriculture, General) which is matched with SOC code 191011 (Animal Scientists). In the end, we assign the SOC code 191011 (Animal Scientists) to CIP code 10508 (taxidermy/taxidermist). In contrast, for example, the CIP code 10699 (Applied Horticulture/Horticultural Business Services, Other) also has no SOC code match. Then, we refer to the nearest broader CIP code which is 10601 (Applied Horticulture/Horticulture Operations, General) which has SOC code 119013 (Farmers, Ranchers, and Other Agricultural Managers). Thus, we assign the SOC code accordingly.

We work with the employment data at the detailed occupation level. There are two inconsistency issues present for the period from 1999 to 2019. First, from 2000 to 2010, 47 SOC codes had moved to different 6-digit codes. For example, SOC code 113041 (Compensation and Benefits Managers) moved to SOC code 113111 (again, titled "Compensation and Benefits Managers") in 2010. Second, 34 SOC codes were divided into two or more detailed 6-digit occupational SOC codes. For example, SOC code 151051 (Computer Systems Analysts) was divided into two SOC codes, 151143 (Computer Network Architects) and 151121 (Computer Systems Analysts) in 2010.

Some SOC codes are present in the crosswalk between fields and occupations, but they are missing in the employment data. This is either due to the division of a SOC code into two or more detailed 6-digit occupational codes in recent years or reporting issues. For instance, in some years, there is employment data only for a broad category. To fix this issue, first, we calculate the growth rates for each year, for all occupation codes. For the period between 2012 and 2016, we do not observe any missing employment data. We start by inferring the missing employment data from 2017 to 2019, then move to 2010 to 2011, and go backward from there on until the year 1999. We identify the SOC codes with missing employment data each year. Then, for the SOC code with missing employment data, we generate a temporary occupation handle variable that equals the SOC code at a broader tier. Before choosing the referred occupation code, we make sure that the selected handle has regular growth rates. For example, in 2010 and 2011, detailed SOC codes 211094 (Community Health Workers) and 211099 (Community and Social

Service Specialists, All Other) were missing. The first step was referring to the broad SOC code 211090 (Miscellaneous Community and Social Service Specialists), however it had irregular growth rates. Thus, we referred to the next broader tier which was minor SOC code 211000 (Counselors, Social Workers, and Other Community and Social Service Specialists). Its growth rates did not show any irregular jumps; hence we chose it as our SOC handle code for the aforementioned missing SOC codes.

In this paper, we restrict the use of the OEWS employment data from 1999 until 2019 for the following reasons. First, there is no crosswalk provided for the SOC code changes between 1980 to 2000. We can retain the reported data for 1999 since it still had similarities to 2000. However, for years 1995 to 1998, the OEWS data creates many challenges for cleaning. Hence, we opt to use the labor force statistics reported by the Bureau of Labor Statistics based on the Current Population Survey (CPS) data.[11] We use the data for characteristics of employed individuals, which specifically groups them by occupation. The CPS data classifies occupations differently than OEWS. We matched the observed SOC codes in our sample with 28 broad CPS occupation categories.[12] We infer the employment and wage statistics for the pre-1999 period for each SOC by using the growth rates of the matched occupation group observed in the CPS data.

In the end, we obtain a series of total employment and mean wage outcomes for each 6-digit SOC code over the 1995-2019 period. In our matching between occupations and fields, 6-digit SOC codes are matched with 6-digit field codes. However, as mentioned above, our analysis uses the aggregated version of fields. Thus, to be able to use these variables about labor market conditions in our analysis, we aggregate this information on

[11] "The Current Population Survey (CPS) is a monthly survey of households conducted by the Bureau of Census for the Bureau of Labor Statistics. It provides a comprehensive body of data on the labor force, employment, unemployment, persons not in the labor force, hours of work, earnings, and other demographic and labor force characteristics." Information retrieved from: https://www.bls.gov/cps/

[12] The categories are as follows. Officials and Administrators, Public Administration; Other Executive, Administrative, and Managerial; Management Related Occupations; Engineers; Mathematical and Computer Scientists, Natural Scientists, Health Diagnosing Occupations, Health Assessment and Treating Occupations, Teachers – College and University; Lawyers and Judges; Other Professional Specialty Occupations, Health Technologists and Technicians, Engineering and Science Technicians; Technicians – except Health, Engineering, and Science; Sales Occupations; Administrative Support – including Clerical; Private Household Occupations; Protective Service Occupations; Service – except Private Household and Protective; Precision Production, Craft, and Repair; Operators, Fabricators, and Laborers; Farming, Forestry, and Fishing.

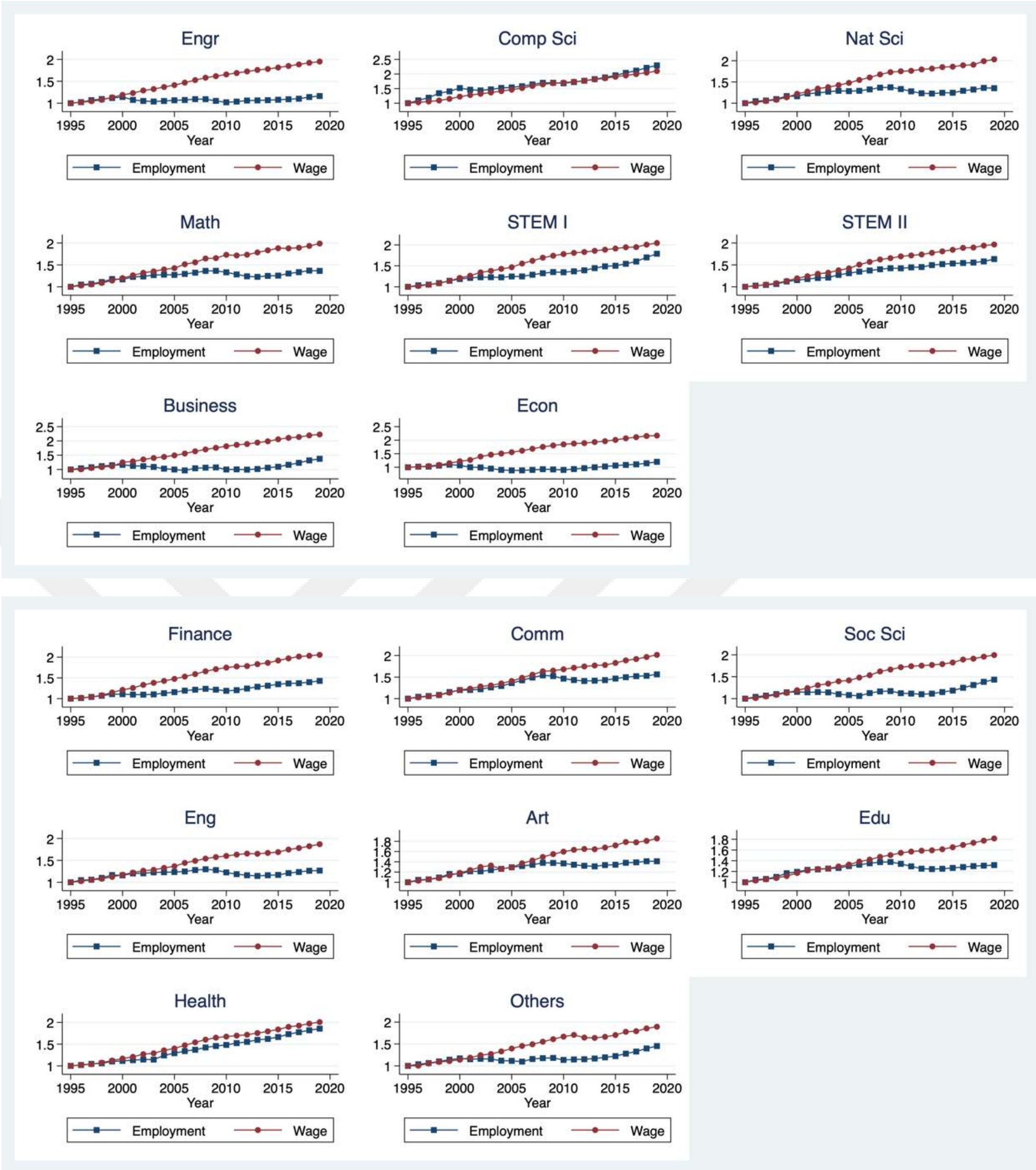
employment and wages as follows. For the sake of simplicity, we define this only for employment, but the same method is used for average wages.

$$E_{it} = \sum_{f} w_{if} \, E_{fot}$$

where $E_{it}$ denotes the total employment for the program $i$ at time $t$. To construct this variable, we first generate a weighting variable ($w_{if}$), which calculates the share of students in each 6 digit-CIP code ($f$) that each program ($i$) consists of in the pre-policy period (i.e., years between 1995 and 2008, both bounds included). Then, we generate a weighted employment variable by multiplying the total employment in the occupation associated with field $f$ (i.e., $E_{fot}$) with the weight measure and summing these terms over all fields constituting that program. Finally, we normalize this variable with respect to 1995, the first year observed in our sample.

Figure 5, Panel A demonstrates the weighted employment and annual mean wages in each aggregate field at the bachelor's level. Since we normalized our values to 1995, both panels provide the growth of employment and wages in each aggregate field. In the period indicated, the annual mean wages have almost doubled or surpassed it, in each field. In contrast, total employment showed only a 25% to 50% growth in Engineering, Natural Sciences, Mathematics, Business, Economics, Finance, Communications, Social Sciences, English, Art, Education, and Others. There is about 75% growth in Science and Engineering I and Science and Engineering II fields. The biggest employment growth is observed in the Computer Science and Health fields, where it almost doubled.

Similarly, Figure 5, Panel B demonstrates the weighted employment and annual mean wages in each aggregate field at the master's level. Again, the annual mean wages have doubled in each aggregate field from 1995 to 2019. The total employment only grew 25% for the Engineering and English fields. The Natural Sciences, Mathematics, Science and Engineering II, Business, Economics, Finance, Communications, Social Sciences, Art, Education, and Others grew by almost or exactly 50%. In contrast, the total employment doubled for the Computer Science, Science and Engineering I, and Health fields.




**Panel A.** Bachelor’s Level

**Notes:** This panel shows the weighted total employment and annual mean wages for the specified field at the bachelor’s level in the United States. The aggregate fields are Engineering, Computer Science, Natural Sciences, Mathematics, Science and Engineering I, Science and Engineering II, Business, Economics, Finance, Communications, Social Sciences, English, Art, Education, Health, and Others.

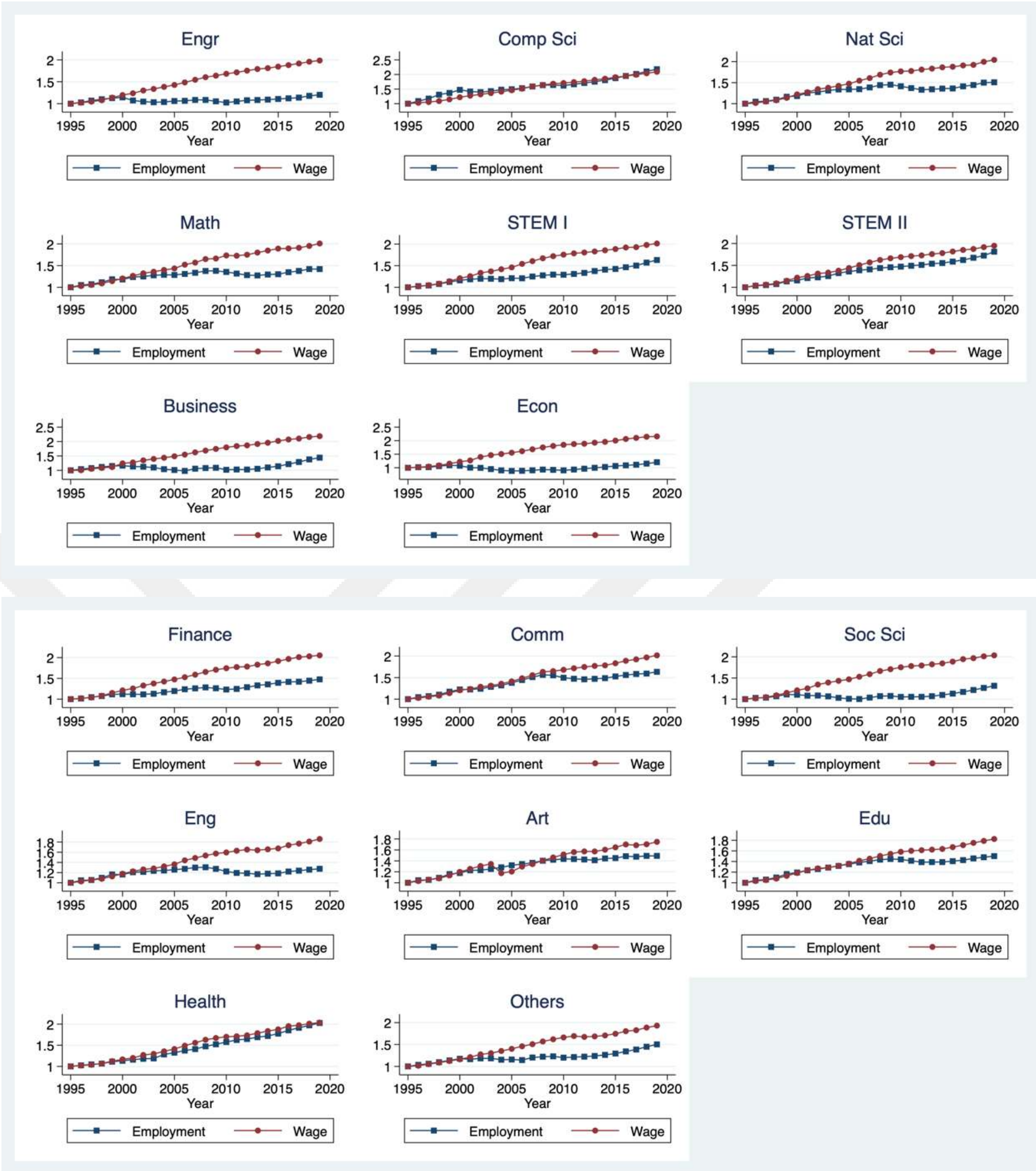



**Figure 5.** Total Employment and Annual Mean Wage in Each Aggregate Field

**Panel B.** Master's Level

**Notes:** This panel shows the weighted total employment and annual mean wages for the specified field at the master's level in the United States. The aggregate fields are Engineering, Computer Science, Natural Sciences, Mathematics, Science and Engineering I, Science and Engineering II, Business, Economics, Finance, Communications, Social Sciences, English, Art, Education, Health, and Others.

## 4.5 *Regional Data*

We argue that there is great heterogeneity that causes the OPT extension policy's impact on foreign graduation to vary across programs. One of the aspects we look at is the economic characteristics of the region in which the universities are located. We use gross domestic product (GDP), income, employment, population, and unemployment data. The U.S. Bureau of Economic Analysis (BEA) provides economic statistics at international, national, regional, and industry levels. We obtain GDP, income, and employment data at the state level from the BEA. The U.S. Census Bureau is a division of the Department of Commerce that collects/provides data on people, places, and the economy in the United States. We obtain population data by state with age characteristics from the U.S. Census Bureau. Finally, we obtain state unemployment statistics from the U.S. Bureau of Labor Statistics (BLS), which is an organization that collects, calculates, and analyzes labor statistics and data vital to the public, businesses, scholars, and government organizations. In this subsection, we describe these data in detail.

From the BEA, we retrieve the "State Personal Income: Revised Estimates for 2022" data file. Our main interest is the per capita personal income data for each state in the United States. We normalize the data with respect to 1995. Then, we calculate the growth rates from 1995/98 to 2008. Similarly, the BLS provides Local Area Unemployment Statistics (LAUS) for each state separately. Our variable of interest is the labor force participation rate. After reshaping and reorganizing the data, we calculate the changes in the labor force participation rate from 1995 to 2008.

The U.S. Census Bureau provides the population data by race, sex, and age characteristics. For the years 2010 to 2019, we obtained the population data from the "Annual Estimates of the Civilian Population by Single Year of Age and Sex for the United States and States: April 1, 2010, to July 1, 2019". For the years 2000 to 2010, we obtained the data from the "Intercensal Estimates of the Resident Population by Single Year of Age and Sex for States and the United States: April 1, 2000, to July 1, 2010". For the years 1990 to 2000, the "Intercensal State and County Characteristics Population Estimates with 1990-Base Race Groups" data files are provided separately for each year at the county level. Our main interest is to see the changes in the total and youth population levels at the state level. We define the youth population as ages between 15 to 24, with both bounds included. As before, we normalize all data with respect to the year

1995. Finally, we calculate the growth rates for total and youth populations from 1995 to 2008.

### 4.6 *Selectivity Data*

We obtain the "Admissions and Test Scores" survey from IPEDS. The survey contains ACT composite, math, English, and writing scores for $25^{th}$ and $75^{th}$ percentiles, and the total number of applicants and admitted students. First, we calculate the admission rates by dividing the total number of applicants by the total number of admitted students. Second, we infer the missing data by imputing the mean of the ACT scores and admission rate for each type of university. Later, in our heterogeneity analysis, we use the admission rate and ACT composite $25^{th}$ percentile scores as university selectivity measures. We also show that our results are robust to other measures of the selectivity available in the data.

# Chapter 5:
# EMPIRICAL METHODOLOGY

## 5.1 *Difference-in-Differences*

To estimate the impact of the OPT extension on international students' degree attainment, we use a difference-in-differences (DD) approach that compares the number of international students graduating from STEM programs with that in non-STEM fields. Before we start the DD analysis, we convert the number of foreign graduates to inverse hyperbolic sine measure as our dependent variable.[13]

We estimate the following two-way fixed effect (TWFE) DD linear model,

$$Y_{sft} = \beta_0 + \beta_1 OPT_{ft} + \delta_{sf} + \delta_t + \epsilon_{sft} \tag{1}$$

where $Y$ represents the inverse hyperbolic sine of the total number of graduates from school *s* and field *f* at time *t*. Our key independent variable $OPT_{ft}$ is a binary indicator that takes the value of 1 when graduates of field *f* are eligible for the extended OPT terms. Our indicator refers to OPT extension policies that were announced in 2008, 2011, and 2012. Since we have data for the number of students graduating each year, we consider the impact of the OPT reforms with a two-year graduation lag. We estimate the impact of each extension cycle separately. Thus, $OPT_{ft}$ equals 1 for the academic programs fulfilling one of the following three requirements in each set of the regressions: (i) the 2010 and later graduates of STEM programs whose students became eligible for the 29-month extended OPT terms in 2008; (ii) the 2013 and later graduates of STEM programs that became eligible in 2011; and (iii) the 2014 and later graduates of STEM programs that became eligible in 2012. In equation (1), the coefficient for the $OPT_{ft}$ measures the changes in the number of international students majoring in STEM fields once the OPT extension became available. We estimate the parameters of this equation separately for bachelor's and master's levels. The variable $\delta_{sf}$ denotes the set of school-field fixed effects to capture possible changes in the characteristics of different programs. The variable $\delta_t$ is the set of year-fixed effects to capture national year-specific patterns in

[13] The inverse hyperbolic sine transformation is given as $sinh^{-1}T = log\left(T + \sqrt{T^2 + 1}\right)$ where T denotes the total number of foreign students.

completion rates. In some specifications, we also control for state-by-year fixed effects, which allows us to control for local year-specific shocks.

For the difference-in-differences method, there are two important assumptions: (i) parallel trend and (ii) exogeneity of the treatment. The parallel trend assumption helps us to measure the internal validity of the results. The key identifying assumption behind the empirical methodology is that the pattern in the number of foreign students getting a degree in a non-STEM field proxies the pattern that would have occurred for the number of students getting a degree in an eligible STEM field in the absence of the OPT extension. The exogeneity of the treatment helps us to interpret our results as the causal impact of the treatment on the outcome. If the OPT extension policy is independent of any other factors that may contribute to changes in completion levels, we can conclude that our treatment is exogenous.

Two potential confounding factors exist in our context: 1) pre-existing trends in the number of foreign students that are specific to particular origin countries and 2) changing labor demand conditions that are likely to be field-specific in the era of the 2008-09 Great Recession. Since the country of origin is not observed in the graduation data, it is not possible to directly control for its confounding role in a DD setup. Instead, we adopt an alternative empirical strategy that compares programs that had similar enrollment patterns in terms of origin countries in the pre-OPT period as explained in the later subsection. To tackle the second issue, we include program-specific variables controlling for employment and wage conditions as independent variables in some specifications. The construction of these variables is explained in the previous section.

## *5.2 Synthetic Control Method*

The Synthetic Control Method (SCM), initially developed by Abadie and Gardeazabal (2003), relies on the information about observed characteristics of the treated and untreated units to construct "synthetic" comparison units that most closely bear resemblance to treated units. To do so, SCM assigns weights to each possible untreated unit and by taking their weights, constructs synthetic controls that mimic the characteristics of the treated units in the pretreatment period. By combining the information from treated units (i.e., STEM programs) and their synthetic controls (i.e., a weighted combination of non-STEM programs), we estimate the impact of the OPT extension in a two-way fixed effect regression model as displayed in equation (1) above.

In this study, we have many treated programs. For instance, the University of Southern California, Biology, Bachelor's program is considered one of the treated programs in our sample. But, for the sake of simplicity, the following SCM methodology will be written for the case in which there is a single treated unit. We have performed this separately for each of the treated programs we have.

The SCM is applied as follows. Let P+1 programs exist, indexed by *p=0, 1, 2,…, P.* The program 0 is the treated program that is affected by a policy change (i.e., the 29 months of OPT extension policy that applies only to STEM majors). All other programs are left untreated, part of the donor pool, where none of the programs are affected by the policy change. Let $\mathbf{X_0}$ be a (M x 1) vector of pre-OPT values of M predictors about the number of international students at our treated program and let **X** be a (M x P) matrix that contains the same predictor variables for the P possible untreated comparison units. The SCM assigns nonnegative weights to each unit in the donor pool, represented by a (P x 1) vector, $\mathbf{W}=(w_1, w_2, w_3,\dots, w_P)$. The optimal weight vector, **W*** is chosen as,

$$\mathbf{W^*} = \text{argmin } (X_0 - XW)' \, V \, (X_0 - XW) \qquad (2)$$

such that all weights are nonnegative and sum up to 1. V is a diagonal matrix where its diagonal values reflect the relative importance of each of the predictor variables. Then, let **Y** be a (T x P) matrix that contains the number of international students for each control program P for the T period, and let $\mathbf{Y_0}$ be a (T x 1) vector containing the same values for the treated program 0. Then, the counterfactual synthetic unit of the number of international students for program 0 is denoted as, $\mathbf{Y_0^* = Y\, W^*}$. In our TWFE regressions, we use $\mathbf{Y_0^*}$ as the control group for $\mathbf{Y_0}$.

## *5.3 Our Specification*

Now, we will provide more details on how we applied the synthetic control method to our sample. First, we make the sample a consistent panel data before we begin our empirical analysis. Then, we divide our sample into eight different subsamples based on their institution type (research, non-research, private, and public), and the program's award level (bachelor's and master's). Each subsample consists of the same type of institutions and programs at the same award level and, i.e., one subsample only contains programs at the public research universities at the bachelor's level. Once we have our subsamples, we perform the synthetic control method at the regional level. Each subsample contains nine different regions following the U.S. Census Bureau's divisions of the United States: New England, Middle Atlantic, East North Central, West North Central, South Atlantic, West South Central, Mountain, and Pacific. We adopted such a strategy to reduce the size of our donor pool to a reasonable level. Otherwise, the estimation would be computationally highly costly. Matching programs of the same region and same university type also allows us to compare more similar units.

Table 5 reports the number of programs in each field category (STEM-2008 eligible, STEM-2010 eligible, STEM-2011 eligible, Business and Economics, Other non-STEM, and total non-STEM), region, and subsample. The donor pool is larger for bachelor's programs (vs. master's) and non-research (vs. research) universities. There is a great deal of variation in donor size, ranging from 22 to 929.

Our treatment group consists of all STEM programs. In each subsample, we find a "synthetic control" unit for each of the treated programs in all regions. A "synthetic control" unit is created as follows. First, we have a donor pool that consists of all the non-STEM programs (untreated) in our sample. Second, we have a set of predictors: the number of foreign students in the years 1996, 1999, 2002, 2005, and 2008; the relative share of each program among foreign students from Africa, Asia, Europe, Latin America, the Middle East, and North America; the relative share of each program among foreign students from the top 1 country, top 3 countries, top 5 countries, and top 10 countries, calculated for each level separately. The ordered ranking of the top 10 origin countries is as follows. At the bachelor's level: China, Saudi Arabia, Japan, Korea, Vietnam, India, Kuwait, Nepal, Brazil, and Taiwan. At the master's level: China, India, Saudi Arabia, Korea, Iran, Taiwan, Japan, Thailand, Bangladesh, and Nigeria.

## Table 5. Number of Programs

| | Region | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | New England | Middle Atlantic | East North Central | West North Central | South Atlantic | East South Central | West South Central | Mountain | Pacific |
| Bachelor's level public research institutions | | | | | | | | | |
| STEM - 2008 eligible | 28 | 48 | 107 | 58 | 106 | 52 | 66 | 69 | 63 |
| STEM - 2011 eligible | 6 | 9 | 25 | 11 | 21 | 9 | 14 | 13 | 15 |
| STEM - 2012 eligible | 7 | 13 | 27 | 13 | 25 | 12 | 16 | 16 | 16 |
| Business and Economics | 14 | 23 | 54 | 30 | 51 | 24 | 33 | 35 | 30 |
| Other non-STEM | 51 | 86 | 209 | 112 | 198 | 101 | 129 | 130 | 112 |
| Total non-STEM | 65 | 109 | 263 | 142 | 249 | 125 | 162 | 165 | 142 |
| Bachelor's level private research institutions | | | | | | | | | |
| STEM - 2008 eligible | 108 | 180 | 120 | 63 | 122 | 36 | 36 | 10 | 74 |
| STEM - 2011 eligible | 30 | 41 | 23 | 12 | 27 | 7 | 6 | 3 | 17 |
| STEM - 2012 eligible | 26 | 48 | 34 | 17 | 30 | 6 | 8 | 3 | 19 |
| Business and Economics | 43 | 87 | 63 | 36 | 67 | 17 | 19 | 5 | 38 |
| Other non-STEM | 171 | 332 | 253 | 142 | 240 | 69 | 71 | 20 | 142 |
| Total non-STEM | 214 | 419 | 316 | 178 | 307 | 86 | 90 | 25 | 180 |
| Bachelor's level public non-research institutions | | | | | | | | | |
| STEM - 2008 eligible | 72 | 159 | 135 | 120 | 194 | 93 | 187 | 64 | 102 |
| STEM - 2011 eligible | 15 | 22 | 24 | 18 | 28 | 10 | 36 | 11 | 24 |
| STEM - 2012 eligible | 20 | 32 | 32 | 29 | 43 | 23 | 42 | 14 | 22 |
| Business and Economics | 42 | 91 | 73 | 58 | 92 | 40 | 79 | 29 | 56 |
| Other non-STEM | 174 | 357 | 299 | 258 | 431 | 202 | 376 | 128 | 202 |
| Total non-STEM | 216 | 448 | 372 | 316 | 523 | 242 | 455 | 157 | 258 |
| Bachelor's level private non-research institutions | | | | | | | | | |
| STEM - 2008 eligible | 112 | 276 | 326 | 240 | 275 | 146 | 145 | 39 | 133 |
| STEM - 2011 eligible | 32 | 62 | 73 | 41 | 55 | 23 | 28 | 10 | 29 |
| STEM - 2012 eligible | 34 | 66 | 80 | 60 | 73 | 33 | 26 | 10 | 33 |
| Business and Economics | 62 | 137 | 151 | 105 | 137 | 63 | 63 | 16 | 67 |
| Other non-STEM | 309 | 679 | 778 | 588 | 691 | 354 | 347 | 87 | 330 |
| Total non-STEM | 371 | 816 | 929 | 693 | 828 | 417 | 410 | 103 | 397 |
| Master's level public research institutions | | | | | | | | | |
| STEM - 2008 eligible | 28 | 43 | 105 | 55 | 94 | 51 | 66 | 67 | 64 |
| STEM - 2011 eligible | 7 | 10 | 21 | 11 | 22 | 9 | 14 | 17 | 13 |
| STEM - 2012 eligible | 7 | 13 | 26 | 12 | 22 | 10 | 13 | 17 | 17 |
| Business and Economics | 13 | 22 | 54 | 26 | 45 | 20 | 30 | 31 | 30 |
| Other non-STEM | 49 | 79 | 207 | 102 | 185 | 96 | 126 | 127 | 114 |
| Total non-STEM | 62 | 101 | 261 | 128 | 230 | 116 | 156 | 158 | 144 |
| Master's level private research institutions | | | | | | | | | |
| STEM - 2008 eligible | 57 | 88 | 36 | 7 | 47 | 4 | 24 | 8 | 24 |
| STEM - 2011 eligible | 11 | 22 | 8 | 3 | 13 | 0 | 4 | 2 | 6 |
| STEM - 2012 eligible | 12 | 22 | 10 | 1 | 13 | 1 | 6 | 2 | 6 |
| Business and Economics | 26 | 39 | 18 | 5 | 27 | 4 | 12 | 4 | 16 |
| Other non-STEM | 102 | 193 | 88 | 25 | 112 | 13 | 51 | 18 | 80 |
| Total non-STEM | 128 | 232 | 106 | 30 | 139 | 17 | 63 | 22 | 96 |
| Master's level public non-research institutions | | | | | | | | | |
| STEM - 2008 eligible | 31 | 73 | 62 | 51 | 88 | 48 | 93 | 19 | 74 |
| STEM - 2011 eligible | 4 | 10 | 10 | 7 | 11 | 4 | 23 | 4 | 17 |
| STEM - 2012 eligible | 10 | 20 | 16 | 15 | 30 | 10 | 24 | 3 | 17 |
| Business and Economics | 15 | 34 | 39 | 32 | 49 | 24 | 43 | 12 | 39 |
| Other non-STEM | 90 | 228 | 181 | 143 | 235 | 130 | 251 | 63 | 163 |
| Total non-STEM | 105 | 262 | 220 | 175 | 284 | 154 | 294 | 75 | 202 |
| Master's level private non-research institutions | | | | | | | | | |
| STEM - 2008 eligible | 31 | 53 | 32 | 19 | 19 | 9 | 14 | 6 | 24 |
| STEM - 2011 eligible | 8 | 7 | 10 | 7 | 7 | 4 | 4 | 2 | 9 |
| STEM - 2012 eligible | 11 | 22 | 10 | 13 | 12 | 6 | 2 | 3 | 11 |
| Business and Economics | 31 | 69 | 65 | 47 | 57 | 24 | 26 | 8 | 39 |
| Other non-STEM | 145 | 310 | 281 | 177 | 195 | 97 | 114 | 36 | 180 |
| Total non-STEM | 176 | 379 | 346 | 224 | 252 | 121 | 140 | 44 | 219 |

Notes: This table reports the number of programs in the sample. Each column specifies a region following the U.S. Census Bureau's nine divisions of the United States. The institutions are categorized into 8 groups: Bachelor's/Master's level Public Research Institutions, Bachelor's/Master's level Private Research Institutions, Bachelor's/Master's level Public Non-Research Institutions, and Bachelor's/Master's level Private Non-Research Institutions. The fields are aggregated into 6 groups: Fields that became STEM eligible in 2008 (STEM - 2008 eligible), fields that became STEM eligible in 2011 (STEM - 2011 eligible), fields that became STEM eligible in 2012 (STEM - 2012 eligible), Business and Economics fields, Other non-STEM fields, and total non-STEM fields. Each cell states the number of programs in the specified category.

Each matching procedure is performed separately for each treated program in each subsample and region. Hence, the donor pool for a treated program consists of all other non-STEM programs in the same region. The SCM matches the pre-OPT values of our predictors for the programs in the donor pool with each treated program in our sample. During this matching process, the SCM assigns weights to each untreated program from the donor pool to create a synthetic unit that closely resembles the characteristics of the treated units in the pre-OPT period. In our empirical analysis, the weighted synthetic outcome variable is the number of foreign student graduates.

The SCM matching and assigning weights procedure is performed for all the untreated units in each region and each subsample. We combine our original data with the synthetic units. Then, we perform two-way fixed effects DD analysis (regression denoted by equation (1)) on the combined data.

### *5.4 Sample Statistics*

Figure 6 demonstrates the total number of foreign graduates who received bachelor's/master's degrees in three different field categories from U.S. institutions. There is a reference line through 2010 because we expect the OPT-extension policy's impact to be lagged. It is important to note that our sample consists of completion data, meaning we observe graduates. Thus, the impact of OPT policy will most likely show a significant impact starting at the earliest two years after the enactment of the policy. We hypothesize two years since in some schools an undergraduate student has time until the end of her second academic year to declare her major.

The blue, red, and green lines demonstrate the STEM fields (programs eligible in 2008), Business, Economics, and Finance (B.E.F.) fields, and all other non-STEM fields, respectively. At the bachelor's level, the number of foreign students is highest in B.E.F, followed by all other non-STEM, and STEM fields. This order changed around 2013-14 when the stock of foreign students in STEM fields surpassed the non-STEM fields. Then, around 2017-18, the stock of foreign students in STEM fields also surpassed the B.E.F. fields, as in 2016 the stock of foreign students started decreasing. Nonetheless, after 2010, we observe an increasing trend in the number of foreign students in any field. Up until the OPT policy change, it looks like STEM and B.E.F. fields follow parallel trends. This is expected, as we hypothesize that (out of all non-STEM fields) B.E.F. fields are the most similar to STEM fields in terms of job opportunities and the number of native and foreign students. After 2010, STEM fields presented a big sharp increase in the stock of foreign students; while for B.E.F. fields, this increase was slower and ended around 2016.

At the master's level, the B.E.F and non-STEM fields follow almost identical patterns. The stock of foreign students is always higher for STEM majors during the 1995-2019 period. We observe an increase for all fields between 2002-04, followed by a slow decline until 2007. Then between 2007 and 2014, there is an increasing trend for all fields. After that, foreign student stock increased sharply until 2010; while non-STEM and B.E.F. fields observed another decline until the end of the indicated period. Since there is also an increasing trend in non-STEM fields; the SCM analysis will help us to better conceptualize the reasoning behind the changes in the number of foreign graduates in each field.

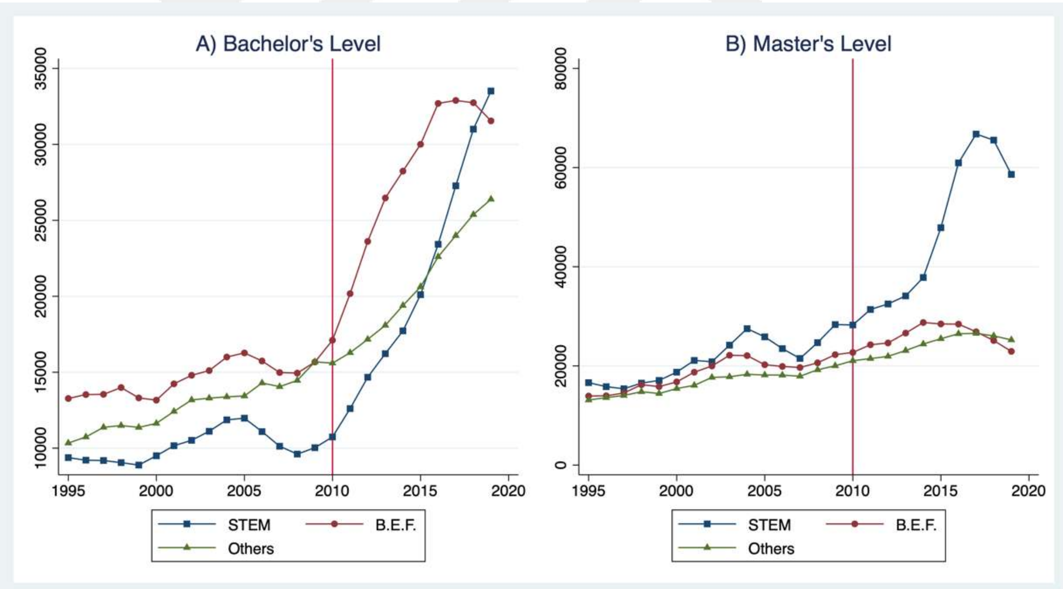



**Figure 6.** Total Number of Foreign Graduates by Level and Field in the United States. STEM vs. non-STEM fields

**Notes:** Each figure shows the number of international students (y-axis) majoring in the field categories in the United States in the indicated graduation year (x-axis). STEM fields include the following aggregate fields: Engineering, Computer Science, Natural Sciences, and Mathematics. B.E.F. denotes the aggregate fields: Business, Economics, and Finance. Others include the following aggregate fields: Communications, Social Sciences, English, Art, Education, Health, and Others. The referenced line is 2010, the hypothesized 2-year lag for the impact of the OPT extension policy.

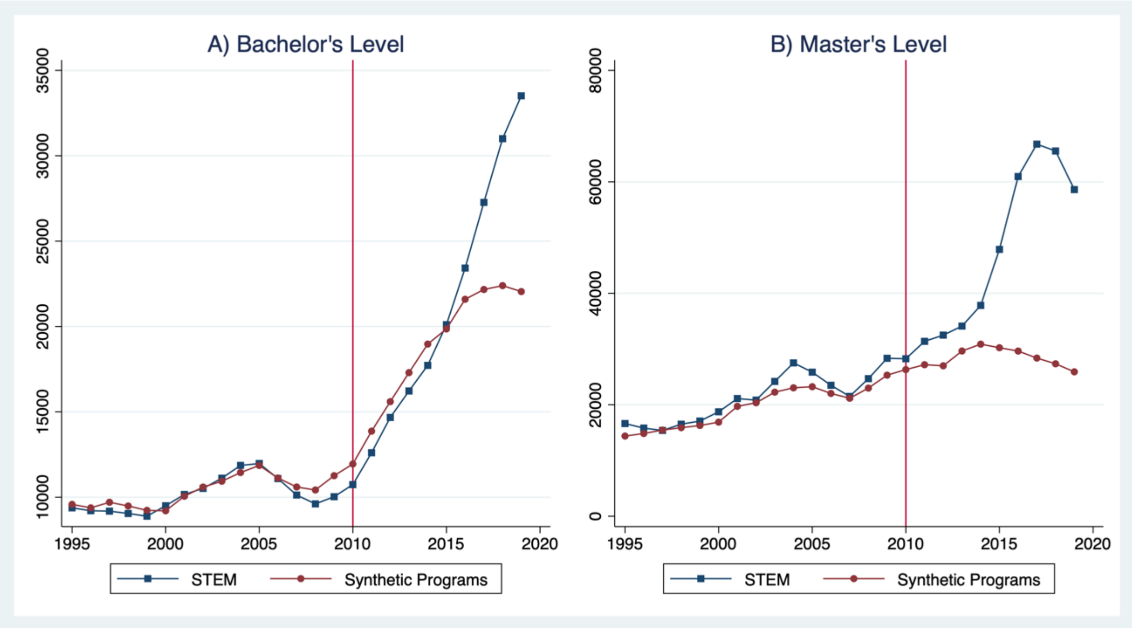



**Figure 7.** Total Number of Foreign Graduates by Level and Field in the United States. STEM vs. Synthetic fields

**Notes:** Each figure shows the number of international students majoring in the specified academic level in STEM and synthetic programs created in the United States. STEM fields include the following aggregate fields: Engineering, Computer Science, Natural Sciences, and Mathematics. Synthetic programs are created by the SCM analysis.

In Figure 7, the blue and red lines demonstrate the STEM fields (programs eligible in 2008) and the synthetic programs created by the SCM, respectively. At both levels, until 2008. After that, they follow a parallel increasing trend until 2014. From that point on, at the bachelor's level, we observe a very sharp increase in foreign graduation, whereas the number of foreign graduates stop increasing around 2016-17, staying about the same. At the master's level, a similar scenario presents itself. Foreign graduation sharply increases until 2017, then decreases in the next two years. In contrast, foreign graduation decreases slowly for synthetic programs. This suggests that the synthetic programs (which are more similar to the STEM programs) also follow an increasing trend after the OPT extension until a certain point—implying that the OPT reform's impact is not going to be as strong as the DD analysis that uses non-STEM programs as control.

**Table 6. Summary Statistics**

| | STEM | | | Non-STEM | | |
|---|---|---|---|---|---|---|
| | Obs | Mean | SD | Obs | Mean | SD |
| Panel A: Bachelor's Level | | | | | | |
| Number of Foreign Students | 150,050 | 2.677 | 10.18 | 279,700 | 3.185 | 12.988 |
| IHS of Foreign Students | 150,050 | 0.728 | 1.13 | 279,700 | 0.868 | 1.173 |
| Weighted Total Employment | 150,050 | 1.33 | 0.306 | 279,700 | 1.203 | 0.203 |
| Weighted Annual Mean Wage | 150,050 | 1.532 | 0.327 | 279,700 | 1.501 | 0.324 |
| Panel B: Master's Level | | | | | | |
| Number of Foreign Students | 60,000 | 14.271 | 46.255 | 146,525 | 7.005 | 24.649 |
| IHS of Foreign Students | 60,000 | 1.691 | 1.727 | 146,525 | 1.205 | 1.463 |
| Weighted Total Employment | 60,000 | 1.331 | 0.347 | 146,525 | 1.229 | 0.277 |
| Weighted Annual Mean Wage | 60,000 | 1.533 | 0.327 | 146,525 | 1.501 | 0.325 |

Notes: This table reports the summary statistics for the control variables used in the two-way fixed effects difference-in-differences analysis. IHS stands for inverse hyperbolic sine. This is our dependent variable in the empirical analysis. Obs denotes the number of programs at the specified level and STEM categories for 25 years. SD denotes the standard deviation. The control variables are weighted by the share of majors (6-digit CIP code) in each program in the pre-OPT period (measured by the total number of students in each 6-digit CIP code by the total number of students in each program in the pre-OPT period).

Table 6 provides the summary statistics for the total number of foreign students, inverse hyperbolic sine of the foreign students, and two control variables, weighted total employment and weighted annual mean wage. At the bachelor’s level, we have almost twice as many observations. The mean of total foreign students is very close between STEM and non-STEM levels at the bachelor’s level. In contrast, at the master’s level, the mean of foreign students is twice as large in STEM fields (14.27) compared to non-STEM fields (7.01). Notice that the average of foreign students in a STEM program is 7 times larger at the master’s level (14.27) compared to the bachelor’s level (2.68). This trend also holds for non-STEM fields; however, the average of foreign students is only twice as much in a non-STEM program at the master’s level (7.01) compared to the bachelor’s level (3.19). The mean of total employment and annual mean wage are almost identical for STEM fields, at both academic levels. The same argument holds for the non-STEM fields. We observe a slight difference between the mean values of the wage variable, between STEM (1.532 and 1.533) and non-STEM fields (1.501 and 1.501), at both levels (bachelor’s and master’s, respectively). In contrast, the mean employment level is higher for STEM fields (1.33 and 1.331) compared to non-STEM fields (1.203 and 1.229), at the bachelor’s and master’s levels, respectively.

# Chapter 6:
# RESULTS

Table 7 states our results for the empirical analysis mentioned in the previous section. Panel A results are for the standard two-way fixed effects difference-in-differences analysis, where the control group consists of all non-STEM programs. Panel B results are for the standard two-way fixed effects performed after SCM, where the synthetic programs are used as the control group. There are four sets of specifications we perform at each academic level. The first set includes only groups of fixed effects as control variables. The second set adds the weighted total employment and the average wages as control variables to the specifications in the first set. Each set contains one regression with the program and year-fixed effects, and another with the program and year-by-state fixed effects. The total number of foreign students in each program in the pre-OPT period plus one is used as the regression weight.

In Panel A, all results are statistically significant. The classical DD analysis shows that OPT reforms have positively impacted the number of foreign students graduating from a U.S. higher education institution at both academic levels. Specification (4) indicates that the 2008 OPT reform has increased the number of foreign graduating students by 15.9% at the bachelor's level. The OPT reform's impact is almost three times larger at the master's level, (specification 8) increasing the number of foreign students by 45%. Our preliminary analysis and figures showed a larger and sharper increase in the number of foreign students who are graduating at the master's level. Thus, we are not surprised by our DD estimates. At the bachelor's level, improvement in the weighted total employment hurts the number of foreign students. This is surprising at first glance; however, we do not have detailed information on the demographics of people who are employed in each occupation or the labor market conditions. Both conditions would help us to conceptualize this negative relationship better. In contrast, the total employment increases the number of foreign students at the master's level. The weighted average wages have no significant impact at either level.

**Table 7. Estimates for the Two-Way Fixed Effects Analysis with DD and SCM**

| | Bachelor's | | | | Master's | | | |
|---|---|---|---|---|---|---|---|---|
| Panel A: Two-way DD | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| OPT | 0.139*** | 0.124*** | 0.165*** | 0.159*** | 0.460*** | 0.487*** | 0.418*** | 0.450*** |
| | (0.0418) | (0.0342) | (0.0371) | (0.0306) | (0.0455) | (0.0418) | (0.0428) | (0.0396) |
| Total Emp | | | -0.172* | -0.263*** | | | 0.333*** | 0.289*** |
| | | | (0.0918) | (0.0720) | | | (0.104) | (0.0966) |
| Ave. Wage | | | 0.385 | 0.215 | | | -0.215 | -0.241 |
| | | | (0.292) | (0.217) | | | (0.265) | (0.244) |
| Panel B: SCM | | | | | | | | |
| OPT | -0.0625* | -0.0585* | 0.00281 | 0.0144 | 0.339*** | 0.338*** | 0.296*** | 0.296*** |
| | (0.0356) | (0.0309) | (0.0305) | (0.0261) | (0.0415) | (0.0384) | (0.0368) | (0.0347) |
| Total Emp | | | -0.550*** | -0.602*** | | | 0.406*** | 0.378*** |
| | | | (0.101) | (0.0842) | | | (0.116) | (0.105) |
| Ave. Wage | | | 0.483* | 0.619*** | | | 0.155 | 0.0442 |
| | | | (0.266) | (0.228) | | | (0.294) | (0.291) |
| Program F.E. | yes | yes | yes | yes | yes | yes | yes | yes |
| Year F.E. | yes | | yes | | yes | | yes | |
| Year by State F.E. | | yes | | yes | | yes | | yes |

Notes: Table shows two-way difference-in-differences (Panel A) and SCM (Panel B) estimates of the impact of the OPT policy changes. The analyses do not include STEM programs that became eligible in year 2011 and 2012. This analysis only examines the impact of the 2008 OPT reform. The treated group consists of all STEM programs, and the control group consists of all non-STEM fields (DD analysis) and synthetic control units created from all non-STEM donor fields (SCM analysis). The total number of foreign students who are completing their respective degrees are specified in inverse hyperbolic sine. The regression is weighted by the total number of foreign students in each program in the pre-OPT period plus one. The OPT is the variable of interest. Some specifications include weighted total employment and average wage as control variables. All specifications include program fixed effects and year or year by state fixed effects. Standard errors are clustered at the program level. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

In Panel B, specification (4) does not show a statistically significant result at the bachelor's level. In contrast, specification (8) persists in a statistically significant result, indicating that the OPT reform positively impacts the number of foreign students by increasing it by 29.6%. Our results suggest that the standard DD analysis with all non-STEM programs as our control group overestimates the impact of the OPT reforms on the total number of foreign students who are completing their bachelor's or master's degrees in a U.S. institution. These results are in line with our preliminary analysis. In Figure 7 (methodology section), we have seen that the total number of foreign students significantly increased for almost all the programs at the bachelor's level. Thus, we do not observe any significant impact at specification (4). On the other hand, at the master's level, we observed the number of foreign students studying STEM majors to increase very sharply compared to all other fields. Hence, we were expecting a statistically significant result at the master's level.

Our empirical analysis also justifies the importance of creating synthetic control units, to better understand the impact of the OPT reform on the STEM programs. When we have a similar set of programs as our control group, we can get a more reliable result.

**Table 8. Comparison Between Average Values of Predictor Variables**

| | Bachelor's | | | Master's | | |
|---|---|---|---|---|---|---|
| | STEM | Non-STEM | Synth | STEM | Non-STEM | Synth |
| Relative Share | | | | | | |
| Africa | 1.672 | 1.256 | 1.464 | 1.625 | 2.085 | 1.586 |
| Asia | 0.912 | 0.808 | 0.888 | 1.046 | 0.784 | 0.993 |
| Europe | 0.911 | 1.353 | 1.113 | 0.851 | 1.47 | 1.008 |
| Latin America | 1.07 | 1.173 | 1.098 | 0.869 | 1.635 | 1.05 |
| Middle East | 1.137 | 0.6 | 0.846 | 1.238 | 1.157 | 1.057 |
| North America | 0.799 | 1.293 | 0.972 | 0.393 | 1.235 | 0.635 |
| Top 1 | 1.057 | 0.837 | 1.077 | 1.514 | 0.99 | 1.597 |
| Top 3 | 0.906 | 0.91 | 0.955 | 1.205 | 0.641 | 1.029 |
| Top 5 | 0.875 | 0.853 | 0.902 | 1.134 | 0.686 | 1.004 |
| Top 10 | 0.932 | 0.821 | 0.904 | 1.049 | 0.77 | 0.999 |
| Total Number of Foreign Students | | | | | | |
| in 1996 | 2.212 | 2.17 | 2.252 | 9.798 | 4.706 | 9.199 |
| in 1999 | 2.134 | 2.206 | 2.217 | 10.581 | 5.162 | 10.086 |
| in 2002 | 2.526 | 2.5 | 2.545 | 12.912 | 6.426 | 12.614 |
| in 2005 | 2.876 | 2.655 | 2.849 | 16.022 | 6.553 | 14.4 |
| in 2008 | 2.308 | 2.628 | 2.504 | 15.302 | 6.798 | 14.248 |

Notes: Table provides a comparison between average values of predictor variables we use to form synthetic units. Our predictor variables are the relative share of each program among foreign students from Africa, Asia, Europe, Latin America, the Middle East, and North America; the relative share of each program among foreign students from the top 1 country, top 3 countries, top 5 countries, and top 10 countries; the number of foreign students in the years 1996, 1999, 2002, 2005, and 2008; calculated for each level separately. STEM column provides the averages for all STEM programs, non-STEM column for all non-STEM programs (control group for DD analysis), and synth column for the synthetic control units created (control group found by SCM analysis).

Table 8 provides a comparison between the average values of predictor variables we use to form synthetic control units. We report the average values for three groups of programs: STEM (i.e., treated group), non-STEM (i.e., control group in classical DD), and synthetic units (i.e., control group created by SCM). At the bachelor's level, the averages of predictor variables are close to each other in all three categories. However, the averages for the synthetic control units are still closer to the averages of STEM programs for each predictor variable compared to non-STEM programs. For instance, the relative dependency on Asian students in foreign graduation is 0.912 for STEM programs, it is 0.808 in non-STEM programs but 0.888 in synthetic programs at the bachelor's level. Similarly, the dependency on top 10 origin countries is more similar between STEM and synthetic units (0.932 vs. 0.904) vis a vis the one between STEM and non-STEM (0.932 vs. 0.821). In other words, our two-way fixed effects regression with synthetic units compares more similar programs compared to classical DD; hence it provides more reliable results. Apparently, the OPT extension does not increase foreign graduation in STEM programs at the bachelor's level.

The averages of the predictor variables are noticeably different between STEM and non-STEM programs at the master's level. It is seen that the STEM and non-STEM programs are demographically very different from each other at the master's level. Thus, it would be better to use synthetic control units, where the averages for each predictor are very close to averages in STEM programs. For example, the relative dependency on Asian students in foreign graduation is 1.046 for STEM programs and 0.784 for non-STEM programs, but it is 0.993 for synthetic programs. Comparably, the dependency on top 10 origin countries is more similar between STEM and synthetic units (1.049 vs. 0.999) vis a vis the one between STEM and non-STEM (1.049 vs. 0.77). Due to the higher level of similarity between treatment and control units, the TWFE with SCM seems to deliver more reliable results at the master's level too.

# Chapter 7:
# HETEROGENEITY ANALYSIS

We continue with several heterogeneity analyses to check whether the OPT visa policy generates different impacts across programs. Table 9 demonstrates our estimates of the 2008 OPT reform, using synthetic programs as a control group. The heterogeneity analysis is performed at different university types (research vs. non-research, public vs. private) and fields (STEM fields eligible in 2008, Engineering, Computer Science, Natural Sciences, and Mathematics). Each cell in the table comes from a separate regression where the analysis is restricted to the university type and field of interest.

The heterogeneity analysis shows that the impact of the 2008 OPT reform on foreign graduation varies greatly based on the university type and the field. At the bachelor’s level, our only statistically significant result is for the non-research public institutions, where we observe a 9.8% decrease in foreign graduation. However, it is important to remember that this is also the group with the largest increase at the master’s level. Thus, foreign students at the master’s level might crowd out the foreign students at the bachelor’s level. At the master’s level, we have statistically significant positive effects for all university types, except for the research private institutions (albeit it’s a positive coefficient). The effect is largest for the non-research universities, increasing foreign graduation by 68.8% and 73.2% at public and private institutions respectively.

The impact of the OPT reform also varies in the different STEM fields. At the bachelor’s level, the largest effect is at the research universities in the mathematics field (at both public and private universities). Foreign graduation in the computer science field in all university types decreases significantly, except for private research universities. However, there might be a crowding-out effect by the master’s level computer science field since there is a significant increase in all university types (again, except private research universities). For natural sciences, at the bachelor's level, we do not find any statistical effect. For engineering, public research and private non-research universities experience an increase.

**Table 9.Heterogeneity Analysis by University Type and Field**

| | Research | | Non-Research | |
|---|---|---|---|---|
| | Public | Private | Public | Private |
| Panel A:Bachelor's Level | | | | |
| Overall | 0.0219 | 0.0337 | -0.0989** | -0.0639 |
| | (0.0416) | (0.0392) | (0.0410) | (0.0487) |
| By Field | | | | |
| Engineering | 0.258*** | 0.0675 | 0.223 | 0.358*** |
| | (0.0604) | (0.0982) | (0.147) | (0.128) |
| Computer Science | -0.268*** | -0.0952 | -0.405*** | -0.401*** |
| | (0.0739) | (0.0986) | (0.0655) | (0.109) |
| Natural Sciences | -0.0839 | -0.0153 | -0.0769 | -8.76e-05 |
| | (0.0729) | (0.0488) | (0.0717) | (0.0473) |
| Mathematics | 0.658*** | 0.663*** | -0.251*** | -0.229*** |
| | (0.124) | (0.0765) | (0.0522) | (0.0358) |
| Panel B:Master's Level | | | | |
| Overall | 0.268*** | 0.103 | 0.688*** | 0.732*** |
| | (0.0353) | (0.0738) | (0.0894) | (0.151) |
| By Field | | | | |
| Engineering | 0.328*** | 0.232 | 0.669*** | 0.979*** |
| | (0.0618) | (0.154) | (0.153) | -0.175 |
| Computer Science | 0.285*** | -0.00883 | 0.624*** | 0.458** |
| | (0.0604) | (0.104) | (0.171) | -0.209 |
| Natural Sciences | -0.0617 | -0.212** | 0.220** | 0.217 |
| | (0.0532) | (0.0931) | (0.105) | -0.224 |
| Mathematics | 0.121 | 0.212 | -0.0176 | 0.332 |
| | (0.111) | (0.140) | (0.141) | -0.382 |
| Controls For Labor Demand | yes | yes | yes | yes |
| Program F.E. | yes | yes | yes | yes |
| Year by State F.E. | yes | yes | yes | yes |

Notes: Table shows two way fixed effects analysis with SCM for the impact of the OPT policy changes in different university types. The purpose of this analysis is to show heterogeneity in the impact of the OPT. The analysis only examines the impact of the 2008 OPT reform. Panel A reports estimates at the bachelor's level and Panel B at the master's level. The estimates are also provided by STEM fields that were targeted in the 2008 OPT reform. The treated group consists of the STEM programs that became eligible in 2008, and the control group consists of all synthetic control units created from all non-STEM donor fields. The total number of foreign students who are completing their respective degrees are specified in inverse hyperbolic sine. The regression is weighted by the total number of foreign students in each program in the pre-OPT period. The OPT is the variable of interest. All specifications include weighted total employment and average wage as control for labor demand (estimates are not reported on the table). All specifications include program fixed effects and year by state fixed effects. Standard errors are clustered at the program level. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

At the master's level, the largest effect is at the non-research universities in the engineering field (at both public and private universities). As mentioned above, the number of foreign graduates also statistically increases in computer science programs, but there is no effect in mathematics. In natural sciences, the results are mixed, and the coefficients are small.

Given that the impact of the OPT extension in foreign graduation greatly varies across university types and fields, a natural question arises: what drives this heterogeneity? Next, we conduct sets of heterogeneity analyses by estimating the impact of the OPT extension in the framework defined in Equation (1) but adding the interaction of the OPT dummy with the program characteristics of interest to the analysis. We test the heterogeneity with respect to 1) the program's network in terms of student origins, 2) the diversity of its student body, 3) the economic characteristics of the local region where the program is located, and 4) its selectivity.

Table 10 demonstrates our estimates of the 2008 OPT reform, using synthetic programs as a control group, but adding the OPT dummy interaction with the share of each program among students from a particular origin in each level from a pre-OPT policy era. Each column in the table comes from a separate regression where the analysis includes all universities in our sample. Columns (1) and (3) look at the interaction of the OPT dummy variable with the share of each program among all foreign students. The interaction terms are positive and statistically significant at both bachelor's and master's levels, suggesting that programs having a larger population of foreign students in the pre-2008 period experienced a larger increase in foreign graduation with the OPT reform. Holding everything else constant, one standard deviation increase in the past share of foreign students generates a 3.2 percentage points (213.3 x 0.0001495 x 100) and a 4.5 percentage points (97.84 x 0.0004578 x 100) larger effect on foreign graduation at the bachelor's and master's levels, respectively.

**Table 10. Heterogeneity Analysis Based on Past Program Networks and Diversity**

| | Bachelor's Level | | Master's Level | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| OPT | -0.0657** | -0.0511* | 0.185*** | 0.212*** |
| | (0.0285) | (0.0307) | (0.0364) | (0.0365) |
| OPT x Share All | 213.3*** | - | 97.84*** | - |
| | (59.13) | - | (22.17) | - |
| OPT x Share Africa | | -108.6* | | 75.10*** |
| | | (60.45) | | (9.215) |
| OPT x Share Asia | | 141.7** | | 81.18*** |
| | | (57.57) | | (24.42) |
| OPT x Share Europe | | 27.68 | | -60.18 |
| | | (128.6) | | (52.22) |
| OPT x Share Latin America | | 14.08 | | -26.46 |
| | | (18.59) | | (24.75) |
| OPT x Share Middle East | | 30.32 | | -38.78 |
| | | (23.33) | | (34.23) |
| OPT x Share North America | | 21.34 | | 76.49 |
| | | (39.37) | | (74.40) |
| Controls For Labor Demand | yes | yes | yes | yes |
| Program F.E. | yes | yes | yes | yes |
| Year by State F.E. | yes | yes | yes | yes |

Notes: Table shows two way fixed effects analysis with SCM for the impact of the OPT policy changes with the interaction of the OPT dummy with the program characteristics of interest for all universities. The analysis only examines the impact of the 2008 OPT reform. Share denotes the share of each program among students of a particular origin in each level. Regressions 1 and 3 considers the interaction of the OPT dummy with share of each program among all foreign students. Regressions 2 and 4 consider the intreactions of OPT dummy variable witht the share of each program among students of origins of Africa, Asia, Europe, Latin America, Middle East, and North America. The treated group consists of the STEM programs that became eligible in 2008, and the control group consists of all synthetic control units created from all non-STEM donor fields. The total number of foreign students who are completing their respective degrees are specified in inverse hyperbolic sine. The regression is weighted by the total number of foreign students in each program in the pre-OPT period. All specifications include weighted total employment and average wage as control for labor demand (estimates are not reported on the table). All specifications include program fixed effects and year by state fixed effects. Standard errors are clustered at the program level. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Columns (2) and (4) look at the interaction of the OPT dummy variable with the share of each program among students from indicated origins. At both levels, we have statistically significant results for OPT and its interactions with the share of each program among students from Africa region and Asia region. At the bachelor’s level, the impact of the OPT extension on foreign graduation is smaller in programs with a larger fraction of African students in the pre-policy period. Holding everything else constant, one standard deviation increase in the past share of African students generates a 2.1 percentage points (i.e., -108.6 x 0.00019 x 100) smaller effect on foreign graduation. In contrast, one standard deviation change in the past share of Asian students generates a 2.8 percentage points (141.7 x 0.0002003 x 100) larger effect on foreign graduation. Other origins also show a positive relationship, however they are statistically insignificant. At the master's level, the impact of the OPT extension on foreign graduation is larger in programs that had a higher fraction of students from Africa and Asia in the past, respectively. Holding everything else constant, one standard deviation increase in the past share of African students generates a 4.4 percentage points (75.10 x 0.0005917 x 100) larger effect on foreign graduation. Similarly, one standard deviation change in the past share of Asian students generates a 4.5 percentage points (81.18 x 0.0005593 x 100) larger effect on foreign graduation. Still, other origins also show a positive but statistically insignificant relationship.

Table 11 demonstrates our estimates of the 2008 OPT reform, using synthetic programs as a control group, but adding the OPT dummy interaction with university selectivity in terms of ACT composite $25^{th}$ percentile scores and economic characteristics of regions of each university. Each column in the table comes from a separate regression where the analysis includes all universities in our sample. Columns (1) and (3) look at the interaction of the OPT dummy variable with the ACT composite 25th percentile score. Our results are statistically significant at the bachelor's level. The OPT extension's impact on foreign graduation increases by 5.1% with each additional point in the ACT score of the incoming class at the bachelor's level. At the master's level, university selectivity is still statistically significant, with each additional point in the ACT score of the incoming class increasing the impact of the OPT extension on foreign graduation by 2.5%. Our results are robust when we use the ACT Composite $75^{th}$ percentile score, the ACT English $25^{th}$ and $75^{th}$ percentile scores, the ACT Math $25^{th}$ and $75^{th}$ percentile scores, and the ACT Writing $25^{th}$ and $75^{th}$ percentile scores.

Columns (2) and (4) look at the interaction of the OPT dummy variable with the per capita income growth from 1995 to 2008, labor force participation growth from 1995 to 2008, and population growth from 1995 to 2008. At the bachelor's level, we do not have any statistically significant results. Similarly, the OPT interactions are still statistically insignificant at the master's level, but the OPT reform's impact is still statistically significant, increasing foreign graduation by 56%. Our results are robust when we use youth population growth from 1995 to 2008 instead of the total population growth and GDP growth from 1995 to 2008 instead of the per capita income growth.

Overall, these estimates show that the characteristics of the region where the academic programs are located do not affect the effectiveness of OPT policies, but the selectivity matters.

**Table 11. Heterogeneity Analysis with University Selectivity and Regional Economic Characteristics**

| | Bachelor's Level | | Master's Level | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| OPT | -1.112*** | -0.126 | -0.277 | 0.560** |
| | (0.135) | (0.224) | (0.239) | (0.229) |
| OPT x ACT score | 0.0509*** | - | 0.0251** | - |
| | (0.00630) | - | (0.0107) | - |
| OPT x Income | | 0.124 | | -0.366 |
| | | (0.289) | | (0.291) |
| OPT x Labor Force | | -0.00996 | | -0.0121 |
| | | (0.0158) | | (0.0208) |
| OPT x Population | | 0.317 | | 0.0217 |
| | | (0.312) | | (0.331) |
| Controls For Labor Demand | yes | yes | yes | yes |
| Program F.E. | yes | yes | yes | yes |
| Year by State F.E. | yes | yes | yes | yes |

Notes: Table shows two way fixed effects analysis with SCM for the impact of the OPT policy changes with the interaction of the OPT dummy with the program characteristics of interest for all universities. The analysis only examines the impact of the 2008 OPT reform. Regressions 1 and 3 considers the interaction of the OPT dummy with ACT 25th percentile scores, which is a measure to capture university's selectivity. Regressions 2 and 4 consider the intreactions of OPT dummy variable with the economic characteristics of the region that the university is located in. Income denotes the percapita income growth from 1995 to 2008. Labor force denotes the labor fore participation level growth from 1995 to 2008. Finally, population denotes the population growth from 1995 to 2008. The treated group consists of the STEM programs that became eligible in 2008, and the control group consists of all synthetic control units created from all non-STEM donor fields. The total number of foreign students who are completing their respective degrees are specified in inverse hyperbolic sine. The regression is weighted by the total number of foreign students in each program in the pre-OPT period. All specifications include weighted total employment and average wage as control for labor demand (estimates are not reported on the table). All specifications include program fixed effects and year by state fixed effects. Standard errors are clustered at the program level. Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

# Chapter 8:
# CONCLUSION

To this day, the United States is still one of the top destinations for international students globally. Attracting thousands of international students who are more inclined to major in STEM fields, is important to understand the impact of policy changes on this group. This paper examines how the OPT extension policies enacted in 2008, 2011, and 2012 impact the number of international students who choose to complete their post-secondary education in the United States.

The TWFE DD analysis indicates that the OPT reform increases foreign graduation by 16% percent at the bachelor's level and 45% at the master's level. The standard DD analysis uses non-STEM fields as a control group with significant differences in the characteristics compared to the treated STEM group. This study shows that the standard DD analysis provides a biased estimate of the OPT policy's impact. By using SCM, we match programs over their past network in foreign student origins and the level of foreign enrollment to create a synthetic control group. We conduct a new set of TWFE DD analyses with synthetically generated control units, and we find that the OPT reform does not affect foreign graduation statistically at the bachelor's level and increases it by only 29% at the master's level. This analysis highlights the importance of constructing a control group that experiences similar qualities in the pre-treatment period.

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# Appendix A: Tables and Graphs for 2011 and 2012 OPT STEM list extension

Earlier in the text, we provided figures 6 and 7 that show the number of foreign students who received their bachelor's or master's degrees in STEM, B.E.F., non-STEM, and synthetic fields between 1995 and 2019. The OPT-extension eligible STEM majors list changed twice in 2011 and 2012. Figures 6A and 7A show the trends in the total number of foreign graduates in Science and Engineering I (2011-eligible) and Science and Engineering II (2012-eligible) aggregate STEM fields, respectively. The reference lines are placed at the 2-year lags.

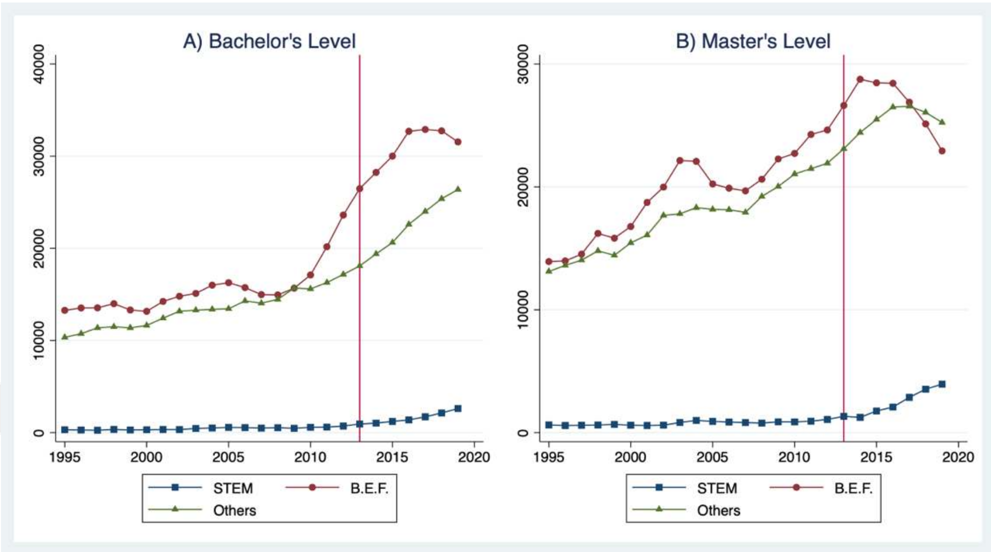
In Figure 6A, on both panels and both the 2011 and 2012 OPT reforms, B.E.F. and other non-STEM fields show similar trends before the 2011-12 OPT reforms, at both levels. However, Science and Engineering I and II do not follow parallel trends. We observe a slight increase in the number of foreign students in the post-OPT period at both levels. The positive trend is sharper and more predominant in Panel A for the 2012 OPT reform. Furthermore, the positive trend is strongest among 2012-eligible STEM fields at the master's level. Both panels in Figure 6A show that non-STEM fields do not constitute a reliable control group for the standard DD analysis, as the parallel trends assumption fails. In contrast, Figure 7A (on both panels and both the 2011 and 2012 OPT reforms) shows that when the synthetic units are used as a control group, the parallel trends assumption holds. All four graphs show a sharp increase in the number of international students graduating from Science and Engineering I (2011-eligible) and Science and Engineering II (2012-eligible) aggregate STEM fields. During the 2011 OPT reform, the number of international students in synthetic fields increased until 2018 at the bachelor's level and 2015 at the master's level, then decreased. In contrast, they do not show any changes during the 2012 OPT reform.

**FIGURE 6A**

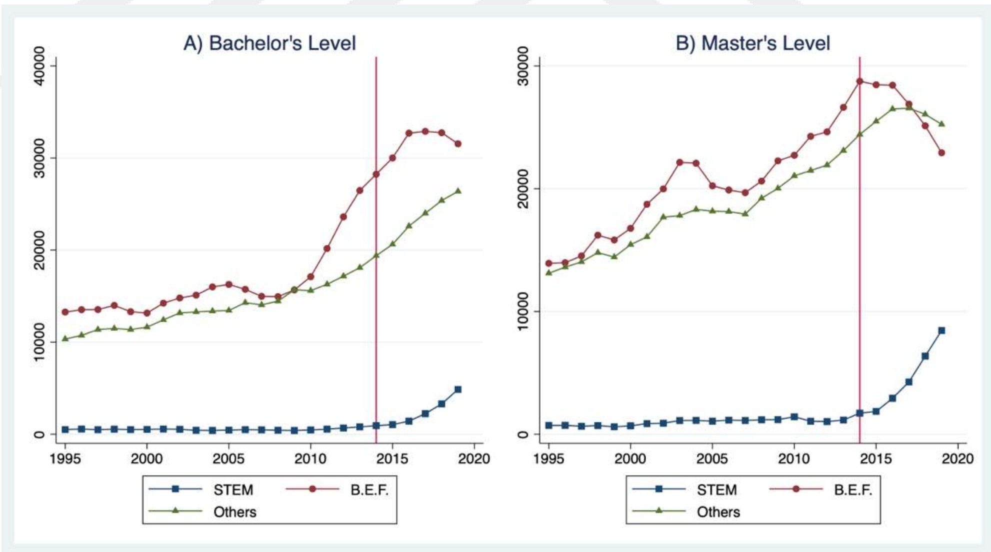
**Total Number of Foreign Graduates by Level and Field in the United States.**

**STEM vs non-STEM**

**A) The 2011 OPT Reform**




**B) The 2012 OPT Reform**

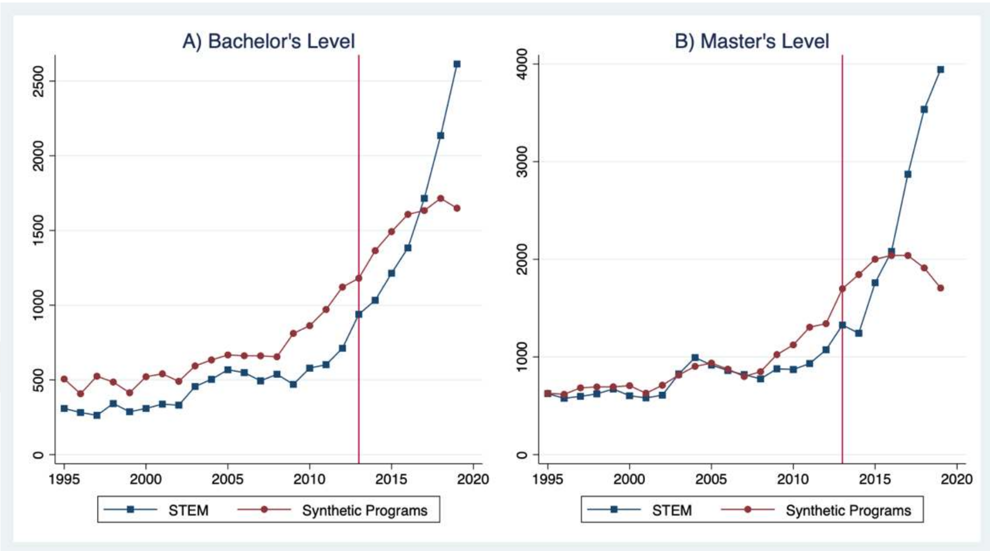



**Notes:** Each figure shows the number of international students(y-axis) majoring in the field categories in the United States in the indicated graduation year(x-axis). STEM fields include the following aggregate fields: Engineering, Computer Science, Natural Sciences, and Mathematics. B.E.F. denotes the aggregate fields: Business, Economics, and Finance. Others include the following aggregate fields: Communications, Social Sciences, English, Art, Education, Health, and Others. For OPT STEM list extension in 2011, the referenced line is 2013, the hypothesized 2-year lag for the impact of the OPT extension policy. For OPT STEM list extension in 2012, the referenced line is 2014, the hypothesized 2-year lag for the impact of the OPT extension policy.

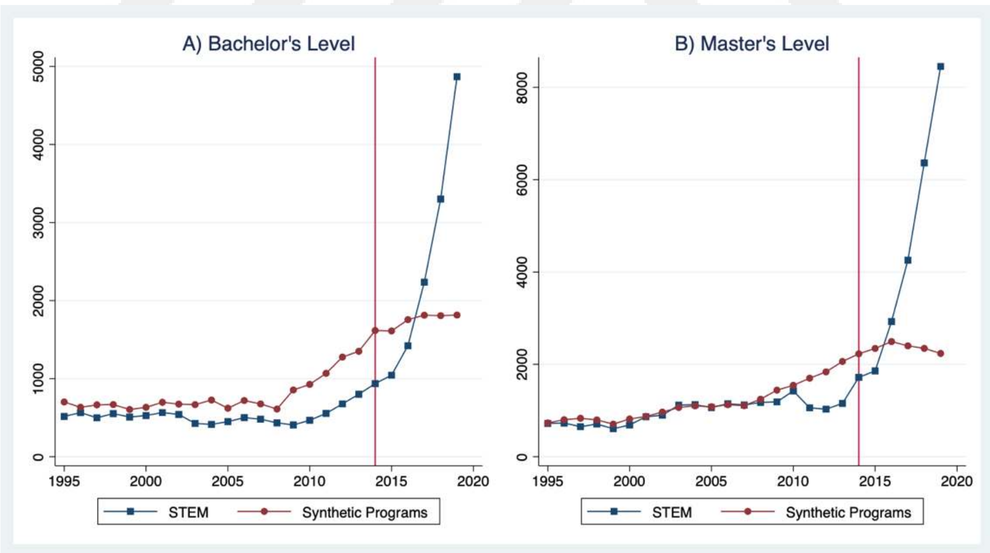
**FIGURE 7A**

**Total Number of Foreign Graduates by Level and Field in the United States. STEM vs Synthetic Fields**

**A) The 2011 OPT Reform**




**B) The 2012 OPT Reform**




**Notes:** Each figure shows the number of international students majoring in the specified academic level in STEM and synthetic programs created in the United States. STEM fields include the following aggregate fields: Engineering, Computer Science, Natural Sciences, and Mathematics. Synthetic programs are created by the SCM analysis.

## TABLE 7A
## Estimates for the Two-Way Fixed Effects Analysis with DD and SCM

### The 2011 OPT Reform

| | Bachelor's | | | | Master's | | | |
|---|---|---|---|---|---|---|---|---|
| Panel A: Two-way DD | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| OPT | 0.288** | 0.274** | 0.269** | 0.265** | 0.372*** | 0.421*** | 0.353*** | 0.405*** |
| | (0.123) | (0.111) | (0.125) | (0.113) | (0.133) | (0.136) | (0.130) | (0.134) |
| Total Emp | | | 0.348** | 0.181* | | | 0.0356 | -0.000963 |
| | | | (0.135) | (0.0946) | | | (0.145) | (0.136) |
| Ave. Wage | | | 0.541* | 0.307 | | | -0.388 | -0.378 |
| | | | (0.324) | (0.233) | | | (0.266) | (0.240) |
| Panel B: SCM | | | | | | | | |
| OPT | -0.00827 | -0.00684 | -0.0165 | 0.00232 | 0.0307 | 0.0289 | 0.0421 | 0.0273 |
| | (0.127) | (0.0981) | (0.136) | (0.101) | -0.144 | (0.133) | (0.143) | (0.135) |
| Total Emp | | | 0.0829 | -0.171 | | | 0.124 | 0.267 |
| | | | (0.289) | (0.222) | | | (0.221) | (0.163) |
| Ave. Wage | | | 0.386 | 0.202 | | | 0.671 | 0.119 |
| | | | (0.705) | (0.571) | | | (0.551) | (0.455) |
| Program F.E. | yes | yes | yes | yes | yes | yes | yes | yes |
| Year F.E. | yes | | yes | | yes | | yes | |
| Year by State F.E. | | yes | | yes | | yes | | yes |

Notes: Table shows two-way difference-in-differences (Panel A) and SCM (Panel B) estimates of the impact of the OPT policy changes. The analysis only examines the impact of the 2011 OPT STEM list extension. The treated group consists of the STEM programs that became eligible in 2011, and the control group consists of all non-STEM fields (DD analysis) and synthetic control units created from all non-STEM donor fields (SCM analysis). The total number of foreign students who are completing their respective degrees are specified in inverse hyperbolic sine. The regression is weighted by the total number of foreign students in each program in the pre-OPT period plus one. The OPT is the variable of interest. Some specifications include weighted total employment and average wage as control variables. All specifications include program fixed effects and year or year by state fixed effects. Standard errors are clustered at the program level. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

### The 2012 OPT Reform

| | Bachelor's | | | | Master's | | | |
|---|---|---|---|---|---|---|---|---|
| Panel A: Two-way DD | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| OPT | 0.179 | 0.169 | 0.181 | 0.171* | 0.673*** | 0.673*** | 0.656*** | 0.657*** |
| | (0.116) | (0.106) | (0.112) | (0.104) | (0.142) | (0.138) | (0.143) | -0.139 |
| Total Emp | | | 0.390*** | 0.226** | | | 0.0324 | -0.00574 |
| | | | (0.139) | (0.0996) | | | (0.143) | -0.134 |
| Ave. Wage | | | 0.602* | 0.360 | | | -0.361 | -0.358 |
| | | | (0.328) | (0.238) | | | (0.270) | -0.243 |
| Panel B: SCM | | | | | | | | |
| OPT | -0.0434 | -0.0292 | -0.0547 | -0.0359 | 0.247 | 0.238* | 0.305* | 0.281** |
| | (0.118) | (0.0979) | (0.114) | (0.0983) | -0.153 | (0.133) | (0.158) | (0.140) |
| Total Emp | | | 0.923** | 0.599** | | | 0.0592 | 0.161 |
| | | | (0.449) | (0.294) | | | (0.338) | (0.310) |
| Ave. Wage | | | 1.537 | 1.159** | | | 2.643*** | 1.947*** |
| | | | (1.052) | (0.591) | | | (0.981) | (0.741) |
| Program F.E. | yes | yes | yes | yes | yes | yes | yes | yes |
| Year F.E. | yes | | yes | | yes | | yes | |
| Year by State F.E. | | yes | | yes | | yes | | yes |

Notes: Table shows two-way difference-in-differences (Panel A) and SCM (Panel B) estimates of the impact of the OPT policy changes. The analysis only examines the impact of the 2012 OPT STEM list extension. The treated group consists of the STEM programs that became eligible in 2012, and the control group consists of all non-STEM fields (DD analysis) and synthetic control units created from all non-STEM donor fields (SCM analysis). The total number of foreign students who are completing their respective degrees are specified in inverse hyperbolic sine. The regression is weighted by the total number of foreign students in each program in the pre-OPT period. The OPT is the variable of interest. Some specifications include weighted total employment and average wage as control variables. All specifications include program fixed effects and year or year by state fixed effects. Standard errors are clustered at the program level. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 7A is a continuation of Table 7 from the text. Each table shows the estimates of two-way FE with classical DD and SCM setup for 2011 and 2012 OPT STEM list extension reforms, respectively. For the 2011 OPT reform, on Panel A, all classical DD results are statistically significant. Specification (4) indicates that the 2011 OPT STEM list extension has increased the number of foreign graduating students by 26.5% at the bachelor's level. The OPT reform's impact is almost two times larger at the master's level, (specification 8) increasing the number of foreign students by 40.5%. In contrast, in Panel B, we do not have any significant results when synthetic programs are used as the control group. This is expected, as in Figure 6A Panel A for the 2011 OPT reform, we did not observe any remarkable change in the number of foreign students at either level.

For the 2012 OPT reform, on Panel A, all classical DD results at the master's level are statistically significant. In contrast, at the bachelor's level, only specification (4) has a 10% significance level, increasing the number of foreign graduating students by 17.1%. Specification (8) suggests that the 2012 OPT STEM list extension increases foreign graduation by 65.7%. In Panel B, we do not observe any significant results at the bachelor's level for the impact of OPT. However, a 5% significance persists at the master's level, increasing the foreign graduation by 28.1%. There is a big difference between the classical DD and SCM results in both tables. This further obliges us to conclude that the classical DD overestimates the impact of the OPT reforms. Thus, using synthetic programs which are more similar to STEM programs gives more reliable results.

Tables 9A, 10A, and 11A are the continuation of our heterogeneity analyses for the 2011 and 2012 OPT reforms. Table 9A examines the heterogeneity in different university types. Panel A reports the results of the 2011 OPT reform. At the bachelor's level, we observe two significant effects. The largest impact is at the private research institutions, increasing foreign graduation from Science and Engineering I aggregate field by 26.4%. In contrast, the 2011 OPT reform decreases foreign graduation by 20.2% at private non-research institutions. At the master's level, the largest impact is at the public research institutions, increasing foreign graduation by 32.3%. Similar to the bachelor's level results, the 2011 OPT reform decreases foreign graduation by 43.6%.

Panel B reports the results of the 2012 OPT reform. At the bachelor's level, foreign graduation increases by 36.5% at private research institutions and decreases by 40.4% at public non-research institutions. At the master's level, we observe the statistically significant positive impact on foreign graduation at both public and private research institutions, increasing by 47.1% and 43.9%, respectively. However, foreign graduation decreases by 70.1% at public non-research institutions. Similar to the 2008 OPT extension policy, we can conclude that the 2011 and 2012 OPT reforms' effects vary based on university types.

**TABLE 9A**

**Heterogeneity Analysis by University Type and Field**

**A) The 2011 OPT Reform**

| | Research | | Non-Research | |
|---|---|---|---|---|
| | Public | Private | Public | Private |
| Panel A:Bachelor's Level | | | | |
| Overall | -0.125 | 0.264** | -0.147* | -0.202** |
| | (0.184) | (0.115) | (0.0812) | (0.0860) |
| Panel B:Master's Level | | | | |
| Overall | 0.323** | -0.451 | -0.0701 | -0.436*** |
| | (0.126) | (0.275) | (0.135) | (0.142) |
| Controls For Labor Demand | yes | yes | yes | yes |
| Program F.E. | yes | yes | yes | yes |
| Year by State F.E. | yes | yes | yes | yes |

Notes: Table shows two way fixed effects analysis with SCM for the impact of the OPT policy changes in different university types. The purpose of this analysis is to show heterogeneity in the impact of the OPT. The analysis only examines the impact of the 2011 OPT reform. Panel A reports estimates at the bachelor's level and Panel B at the master's level. The estimates are also provided by STEM fields that were targeted in the 2011 OPT reform. The treated group consists of the STEM programs that became eligible in 2011, and the control group consists of all synthetic control units created from all non-STEM donor fields. The total number of foreign students who are completing their respective degrees are specified in inverse hyperbolic sine. The regression is weighted by the total number of foreign students in each program in the pre-OPT period. The OPT is the variable of interest. All specifications include weighted total employment and average wage as control for labor demand (estimates are not reported on the table). All specifications include program fixed effects and year by state fixed effects. Standard errors are clustered at the program level. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

**B) The 2012 OPT Reform**

| | Research | | Non-Research | |
|---|---|---|---|---|
| | Public | Private | Public | Private |
| Panel A:Bachelor's Level | | | | |
| Overall | -0.00583 | 0.365*** | -0.404*** | -0.280 |
| | (0.172) | (0.120) | (0.0982) | (0.208) |
| Panel B:Master's Level | | | | |
| Overall | 0.471*** | 0.439* | -0.701*** | 0.0453 |
| | (0.145) | (0.256) | (0.236) | (0.220) |
| Controls For Labor Demand | yes | yes | yes | yes |
| Program F.E. | yes | yes | yes | yes |
| Year by State F.E. | yes | yes | yes | yes |

Notes: Table shows two way fixed effects analysis with SCM for the impact of the OPT policy changes in different university types. The purpose of this analysis is to show heterogeneity in the impact of the OPT. The analysis only examines the impact of the 2012 OPT reform. Panel A reports estimates at the bachelor's level and Panel B at the master's level. The estimates are also provided by STEM fields that were targeted in the 2012 OPT reform. The treated group consists of the STEM programs that became eligible in 2012, and the control group consists of all synthetic control units created from all non-STEM donor fields. The total number of foreign students who are completing their respective degrees are specified in inverse hyperbolic sine. The regression is weighted by the total number of foreign students in each program in the pre-OPT period. The OPT is the variable of interest. All specifications include weighted total employment and average wage as control for labor demand (estimates are not reported on the table). All specifications include program fixed effects and year by state fixed effects. Standard errors are clustered at the program level. Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 10A examines the heterogeneity relationship based on programs' past networks measured by the share of international students from different countries of origin. Panel A reports the results of the 2011 OPT reform. The interaction terms are positive and statistically significant at the bachelor's level, suggesting that programs having a larger population of foreign students in the pre-2008 period experienced a larger increase in foreign graduation with the OPT reform. Holding everything else constant, one standard deviation increase in the past share of foreign students generates a 14.8 percentage points (3649 x 0.0000406 x 100) larger effect on foreign graduation at the bachelor's level. We do not have a significant impact at the master's level. Columns (2) and (4) look at the interaction of the OPT dummy variable with the share of each program among students from indicated origins. At the bachelor's level, we have statistically significant results for OPT and its interactions with the share of each program among students from Africa, Asia, and Europe regions. The impact of the OPT extension on foreign graduation is smaller in programs with a larger fraction of African and European students in the pre-policy period. Holding everything else constant, one standard deviation increase in the past share of African students and European students generate a 21.8 percentage points (-3,503 x 0.0000621 x 100) and a 10.6 percentage points (-2,714 x 0.0000389 x 100) smaller effect on foreign graduation. In contrast, one standard deviation increase in the past share of Asian students generates a 25.6 percentage points (4,508 x 0.0000568 x 100) larger effect on foreign graduation.

**TABLE 10A**
**Heterogeneity Analysis Based on Past Program Networks and Diversity**
**A) For 2011 OPT Reform**

| | Bachelor's Level | | Master's Level | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| OPT | -0.300*** | -0.233*** | 0.00739 | -0.202* |
| | (0.0963) | (0.0758) | (0.108) | (0.109) |
| OPT x Share All | 3,649*** | - | -440.6 | - |
| | (1,235) | - | (624.0) | - |
| OPT x Share Africa | | -3,503*** | | -238.4 |
| | | (1,346) | | (372.2) |
| OPT x Share Asia | | 4,508*** | | 5,256*** |
| | | (493.3) | | (1,045) |
| OPT x Share Europe | | -2,714* | | -1,791** |
| | | (1,477) | | (774.0) |
| OPT x Share Latin America | | 374.4 | | -676.2*** |
| | | (637.9) | | (171.6) |
| OPT x Share Middle East | | -45.06 | | 9.883 |
| | | (476.4) | | (930.1) |
| OPT x Share North America | | 105.2 | | 1,246 |
| | | (576.7) | | (939.0) |
| Controls For Labor Demand | yes | yes | yes | yes |
| Program F.E. | yes | yes | yes | yes |
| Year by State F.E. | yes | yes | yes | yes |

Notes: Table shows two way fixed effects analysis with SCM for the impact of the OPT policy changes with the interaction of the OPT dummy with the program characteristics of interest for all universities. The analysis only examines the impact of the 2011 OPT reform. Share denotes the share of each program among students of a particular origin in each level. Regressions 1 and 3 considers the interaction of the OPT dummy with share of each program among all foreign students. Regressions 2 and 4 consider the intreactions of OPT dummy variable witht the share of each program among students of origins of Africa, Asia, Europe, Latin America, Middle East, and North America. The treated group consists of the STEM programs that became eligible in 2011, and the control group consists of all synthetic control units created from all non-STEM donor fields. The total number of foreign students who are completing their respective degrees are specified in inverse hyperbolic sine. The regression is weighted by the total number of foreign students in each program in the pre-OPT period. All specifications include weighted total employment and average wage as control for labor demand (estimates are not reported on the table). All specifications include program fixed effects and year by state fixed effects. Standard errors are clustered at the program level. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

### B) For 2012 OPT Reform

| | Bachelor's Level | | Master's Level | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| OPT | -0.520*** | -0.472*** | -0.409*** | -0.439*** |
| | (0.0950) | (0.0941) | (0.143) | (0.158) |
| OPT x Share All | 3,808*** | | 1,094*** | |
| | (566.0) | | (351.0) | |
| OPT x Share Africa | | -685.5 | | -971.1 |
| | | (548.6) | | (1,032) |
| OPT x Share Asia | | 3,518*** | | -522.3 |
| | | (1,162) | | (579.8) |
| OPT x Share Europe | | -955.1 | | 23.14 |
| | | (2,869) | | (235.1) |
| OPT x Share Latin America | | 602.2 | | 1,119 |
| | | (925.2) | | (765.2) |
| OPT x Share Middle East | | 115.7 | | 816.7 |
| | | (248.2) | | (554.0) |
| OPT x Share North America | | -392.6 | | 613.0 |
| | | (688.7) | | (372.9) |
| Controls For Labor Demand | yes | yes | yes | yes |
| Program F.E. | yes | yes | yes | yes |
| Year by State F.E. | yes | yes | yes | yes |

Notes: Table shows two way fixed effects analysis with SCM for the impact of the OPT policy changes with the interaction of the OPT dummy with the program characteristics of interest for all universities. The analysis only examines the impact of the 2012 OPT reform. Share denotes the share of each program among students of a particular origin in each level. Regressions 1 and 3 considers the interaction of the OPT dummy with share of each program among all foreign students. Regressions 2 and 4 consider the intreactions of OPT dummy variable witht the share of each program among students of origins of Africa, Asia, Europe, Latin America, Middle East, and North America. The treated group consists of the STEM programs that became eligible in 2012, and the control group consists of all synthetic control units created from all non-STEM donor fields. The total number of foreign students who are completing their respective degrees are specified in inverse hyperbolic sine. The regression is weighted by the total number of foreign students in each program in the pre-OPT period. All specifications include weighted total employment and average wage as control for labor demand (estimates are not reported on the table). All specifications include program fixed effects and year by state fixed effects. Standard errors are clustered at the program level. Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

At the master's level, we observe significant impacts for past networks from Asia, Europe, and Latin America. Holding everything else constant, one standard deviation increase in the past share of European and Latin American students generate a 14.8 percentage points (-1,791 x 0.0000825 x 100) and 10.9 percentage points (-6,76 x 0.0001612 x 100) smaller effect on foreign graduation. In contrast, one standard deviation increase in the past share of Asian students generates a 35.2 percentage points (5,256 x 0.0000669 x 100) larger effect on foreign graduation.

Panel B reports the results of the 2012 OPT reform. The interaction terms are positive and statistically significant at both bachelor's and master's levels, suggesting that programs having a larger population of foreign students in the pre-2008 period experienced a larger increase in foreign graduation with the OPT reform. Holding everything else constant, one standard deviation increase in the past share of international students generates a 17.1 percentage points (3,808 x 0.0000449 x 100) and 9.8 percentage points (1,094 x 0.0000899 x 100) larger impact on foreign graduation at bachelor's and master's levels, respectively. Columns 2 and 4 show only one significant effect, that is one standard deviation increase in the past share of Asian students generates a 17.1 percentage points (3,518 x 0.0000486 x 100) larger impact on foreign graduation at the bachelor's level.

**TABLE 11A**
**Heterogeneity Analysis with University Selectivity and Regional Economic Characteristics**

**A) The 2011 OPT Reform**

| | Bachelor's Level | | Master's Level | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| OPT | -1.836*** | 0.430 | -0.273 | -0.691 |
| | (0.384) | (0.749) | (0.662) | (0.642) |
| OPT x ACT score | 0.0800*** | - | 0.00940 | - |
| | (0.0183) | - | (0.0301) | - |
| OPT x Income | | -0.603 | | 0.747 |
| | | (0.971) | | (0.756) |
| OPT x Labor Force | | -0.221 | | 0.292 |
| | | (0.707) | | (0.905) |
| OPT x Population | | 0.0246 | | -0.0644 |
| | | (0.0452) | | (0.0441) |
| Controls For Labor Demand | yes | yes | yes | yes |
| Program F.E. | yes | yes | yes | yes |
| Year by State F.E. | yes | yes | yes | yes |

Notes: Table shows two way fixed effects analysis with SCM for the impact of the OPT policy changes with the interaction of the OPT dummy with the program characteristics of interest for all universities. The analysis only examines the impact of the 2011 OPT reform. Regressions 1 and 3 considers the interaction of the OPT dummy with ACT 25th percentile scores, which is a measure to capture university's selectivity. Regressions 2 and 4 consider the intreactions of OPT dummy variable with the economic characteristics of the region that the university is located in. Income denotes the percapita income growth from 1995 to 2008. Labor force denotes the labor fore participation level growth from 1995 to 2008. Finally, population denotes the population growth from 1995 to 2008. The treated group consists of the STEM programs that became eligible in 2011, and the control group consists of all synthetic control units created from all non-STEM donor fields. The total number of foreign students who are completing their respective degrees are specified in inverse hyperbolic sine. The regression is weighted by the total number of foreign students in each program in the pre-OPT period. All specifications include weighted total employment and average wage as control for labor demand (estimates are not reported on the table). All specifications include program fixed effects and year by state fixed effects. Standard errors are clustered at the program level. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

**B) The 2012 OPT Reform**

| | Bachelor's Level | | Master's Level | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| OPT | -2.136*** | 0.126 | -1.957*** | 0.959 |
| | (0.344) | (0.507) | (0.642) | (0.678) |
| OPT x ACT score | 0.0873*** | | 0.0740*** | |
| | (0.0170) | | (0.0283) | |
| OPT x Income | | -0.681 | | -1.459 |
| | | (0.611) | | (0.889) |
| OPT x Labor Force | | 1.126** | | -0.963 |
| | | (0.497) | | (0.771) |
| OPT x Population | | 0.0678 | | -0.0849 |
| | | (0.0492) | | (0.0560) |
| Controls For Labor Demand | yes | yes | yes | yes |
| Program F.E. | yes | yes | yes | yes |
| Year by State F.E. | yes | yes | yes | yes |

Notes: Table shows two way fixed effects analysis with SCM for the impact of the OPT policy changes with the interaction of the OPT dummy with the program characteristics of interest for all universities. The analysis only examines the impact of the 2012 OPT reform. Regressions 1 and 3 considers the interaction of the OPT dummy with ACT 25th percentile scores, which is a measure to capture university's selectivity. Regressions 2 and 4 consider the intreactions of OPT dummy variable with the economic characteristics of the region that the university is located in. Income denotes the percapita income growth from 1995 to 2008. Labor force denotes the labor fore participation level growth from 1995 to 2008. Finally, population denotes the population growth from 1995 to 2008. The treated group consists of the STEM programs that became eligible in 2012, and the control group consists of all synthetic control units created from all non-STEM donor fields. The total number of foreign students who are completing their respective degrees are specified in inverse hyperbolic sine. The regression is weighted by the total number of foreign students in each program in the pre-OPT period. All specifications include weighted total employment and average wage as control for labor demand (estimates are not reported on the table). All specifications include program fixed effects and year by state fixed effects. Standard errors are clustered at the program level. Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 11A examines whether OPT reforms' impacts differ based on university selectivity and regional economic characteristics. Both Panel A and B supports that the university selectivity plays a role in the OPT policy's impact variation. The 2011 OPT reform increases bachelor's level foreign graduation by 8% for a point increase in the ACT score of the incoming class. Similarly, the 2012 OPT reform increases foreign graduation by 8.7% and 7.4% at the bachelor's and master's levels, respectively. We do not observe any significant effect of the 2011 OPT reform based on the characteristics of the region where the academic programs are located. However, the 2012 OPT policy increases foreign graduation for a rise in the labor force participation rate.