Comparative Immigration Policies and the Resource Effects of International Students in U.S. Higher Education*

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Abstract

This paper studies the causal effect of resources in the context of U.S. higher education, exploiting an exogenous resource shift brought on by international students. I leverage a restrictive immigration policy change in the U.K. that induced more students from former British colonies to enroll in U.S. universities. I find more international enrollment leads to more domestic completion, especially in public four-year institutions. Additionally, I find positive cross-degree-level effects of international students in master's degree programs on domestic students in bachelor's degree programs. The positive impact is most likely through cross-subsidization of tuition, serving as evidence of resource effects.

JEL Codes: F22, I21, I22, I23, J15, J68

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I Introduction

In the United States, the higher education sector has been confronting the worsening scarcity of financial resources for decades. In the face of declining state funding, one way in which public universities have responded is by enrolling more international students in exchange for higher out-of-state tuition revenue (Bound et al., 2020). There is also ample anecdotal evidence that many colleges and universities treat international students as "cash cows," especially through revenue-generating master's programs (Cantwell, 2015). As the number of international students in the global market grows steadily in recent decades, from around 2 million in 2000 to well over 6 million (UNESCO Institute for Statistics, 2019), there have been ongoing debates over the effect international students have in U.S. higher education, and to what extent immigration policies need to be adjusted to attract or restrict this group as a result.

Yet evidence on the resource effects of international students in higher education is relatively mixed. On the one hand, the selection problem of migration decision and the lack of high quality administrative data makes identifying the causal effect of international students challenging. This paper improves upon both dimensions and provides new causal evidence of how international students affect domestic students through financial resources. On the other hand, the existing research has largely neglected how comparative immigration policies can influence international students' choice of destinations. This paper provides a new mechanism for high-skilled international migration and human capital investment decision-making.

In this paper, I examine the causal effect of resources on U.S domestic student college completion by leveraging an exogenous resource shift brought on by international students. I exploit a restrictive immigration policy change in the U.K., the other top destination country for international students, that induced more students from former British colonies to enroll in U.S. universities. Since the U.K. immigration policy change was not made in response to circumstances in the U.S. higher education system, it only affected international students and not U.S. domestic students, which allows me to overcome the selection concerns endemic to prior research. Additionally, by using administrative records of all new international students in the U.S. between 2003 and 2015 newly obtained through a Freedom of Information Act (FOIA) request, I improve substantially upon existing studies in terms of data quality.

The U.K. immigration policy change exploited in this paper affects post-graduation visas where international students are allowed to work for a certain period of time without having to secure an official employer sponsorship. Prior to 2012, the U.K. had a 2-year post-graduation visa policy called the Tier 1 (Post-Study Work) program. In March 2011, the

U.K. government announced that the Tier 1 (Post-Study Work) program would be cancelled starting April 2012, after which international students could only stay for two to four months after graduation, depending on their program length. In contrast, during the same period, the U.S. allowed international students with non-Science, Technology, Engineering, and Math (STEM) degrees to stay and work for 12 months after graduation, and 29 months for those with STEM degrees.[1] If the ability to stay and work in the host country plays a role in the decision-making process of a prospective international student, especially those who plans to study in a STEM field, the U.K. policy change made the U.S. a relatively more attractive option for international students.

The U.K. immigration policy change disproportionately affected students from former British colonies, compared with those from non-former British colonies. This difference likely stems from the fact that, in the absence of the immigration policy change, historical networks and familiarity with the British education system makes the U.K. the first choice for many students from former British colonies. However, after the U.K. immigration policy change, especially students in STEM majors may find the U.K. relatively less attractive because of additional barriers to entering the labor market in that country after graduation. This heterogeneous response to the policy change forms the basis of my empirical strategy, allowing me to cleanly identify the change in new international enrollment in U.S. university programs that is driven only by the U.K. immigration policy change. Specifically, in the first part of the paper, I implement a triple-difference empirical strategy to estimate how the number of new international students in U.S. programs changes among students from former British colonies in STEM programs relative to those in non-STEM programs, in response to the U.K. immigration policy change, and how this change relates to the changes in new international enrollment for students from non-former British colonies whose programs differ in STEM status. This approach allows me to account for any common trends that might affect enrollment in STEM programs in U.S. universities over time. I find that the U.K. immigration policy change significantly increases new international enrollment from former British colonies in STEM programs; and this increase is driven entirely by enrollment in master's degree programs.

In the second part of the paper, I estimate the effect of new international student enrollment on domestic students' college completion using an instrumental variable (IV) identification strategy. Specifically, the total number of new international students in each program, defined at the school-major-degree level, is instrumented using the sum of the av-

[1]The U.S. first introduced the post-graduation visa program, or the Optional Practical Training (OPT), in 2008. In 2016, the U.S. government extended the post-graduation visa for students with STEM degrees, from 29 months to 36 months.

erage number of international students from non-former British colonies in baseline years of 2003-2010, the years preceding the announcement of the U.K. immigration policy change, and the predicted number of new international students from former British colonies induced from the restrictive U.K. immigration policy change. The predicted number of students from former British colonies is the predicted number of colonial students from the triple difference estimation weighted by the ratio of the program-specific share of international students from former British colonies in baseline years to the average share of international students from former British colonies across programs in baseline years. The U.K. immigration policy change serves as an exogenous shifter that provides shocks that are arguably as-good-as randomly assigned conditional on observables and fixed effects. Together, the instrument provides plausibly exogenous variations to new international enrollment in U.S. university programs, which improves upon the existing immigration literature that heavily replies on traditional shift-share IVs where neither the "shift" nor the "share" is driven by an arguably-exogenous policy variation (Borusyak et al., 2022; Goldsmith-Pinkham et al., 2020). I find that one additional new international student at the university program level leads to about 0.7 more U.S. domestic students to complete a postsecondary degree four years later. Additionally, I find a significant cross-degree level effect that an additional international master's student leads to an increase of about 0.6 domestic completions four years later at the bachelor's degree level.

In the third part of the paper, I explore the potential mechanisms. There are two main potential channels through which international students could affect domestic students – peer effect and resource effect. Since the exogenous increase in international enrollment comes from STEM master's programs, it is unlikely that domestic students in those master's programs would respond by switching majors. The cross-degree level effect further rules out the potential peer effect channel. Instead, I find the resource effect channel to be the main mechanism. After the restrictive U.K. immigration policy change, U.S. university programs received substantially more tuition revenue from new international students, especially those from former British colonies. Since most university programs have some control over how tuition revenue is spent, it is likely that they would subsidize domestic students in the form of financial aid using part of the tuition revenue from international students.

The positive effect of international enrollment on U.S. domestic student college completion is concentrated in public four-year universities, with one additional new international student leading to an increase of 1.1 domestic completions four years later. And for public four-year universities, the amount of increase in tuition revenue from former British colonial students makes up four years of in-state tuition and fees for 1.1 in-state students, which aligns closely with the magnitude of the main effects. This also suggests that the main chan-

nel of the positive impact of international student enrollment on domestic student college completion is through cross-subsidization of tuition. I additionally examine financial aid and university finances as outcomes. Suggestive evidence shows that international enrollment has positive effects on the number and amount of institutional grant awards, as well as net tuition revenue, net auxiliary enterprises revenues, and expenditures on instruction, research, student service and academic support.

Additionally, I examine the heterogeneous treatment effect of new international enrollment in master's programs on U.S. domestic college completion in bachelor's programs by gender, race/ethnicity, and university selectivity level. I find that the positive effect is concentrated among male, white, black and Asian domestic students. Female and Hispanic domestic students' college completion remain unaffected. This could be due to the underrepresentation of female and Hispanic students in STEM programs from which the first-stage variation draws (Arcidiacono et al., 2016), or that these groups are already heavily subsidized. Since data on domestic student enrollment at the program level are not available, I am unable to distinguish whether the positive effect is through increase in domestic enrollment or higher completion rate.

The positive average effect I find is driven by highly-selective and selective public four-year universities, as opposed to elite or non-selective public universities or private universities. This finding is consistent with the fact that elite universities with large endowments are unlikely to suffer from serious resource constraints. They generally provide generous financial aid to domestic students, and like other private universities and colleges, these universities might be unable to expand programs due to seat constraint or prestige concerns. On the other hand, non-selective universities would most likely be unattractive or unknown to most international students. Thus, it is the middle-tier public universities that are relatively seat-flexible and in need of financial resources that have the largest marginal benefit from an increase in international students. My results show that it is indeed those institutions that experience the largest effect from international students. This finding also relates to stratification in higher education, where less selective universities are generally affected by a lack of resources (Bound et al., 2010; Hoxby, 2009), and thus are incentivized to admit more international students for the additional funding. My results suggest that the increase in international enrollment helps reduce cross-institution stratification.

This paper contributes to several strands of literature. First, this paper contributes to the literature on higher education finances and how additional financial resources affect student outcomes in postsecondary institutions (Bound and Turner, 2007; Chakrabarti et al., 2020; Deming and Walters, 2017). Although a few recent studies have investigated the relationship between undergraduate international enrollment and university revenue in U.S.

public universities and find generally positive relationships (Bound et al., 2021; Cantwell, 2015), the evidence on revenue-generating master's programs is still lacking. This paper documents the first program-level evidence on how exogenous inflows of new international students impact tuition revenue of master's programs, and subsequently, how the increase in program tuition revenue benefits domestic undergraduate students. The findings are consistent with decentralized university budget models where schools and departments have some control over revenues and expenditures.

Second, this paper contributes to the literature on the effect of immigration policies on immigrant populations. In the context of international students, existing research generally finds that restrictive U.S. immigration policies lowers high-quality foreign enrollment (Kato and Sparber, 2013; Shih, 2016). However, it is unclear what alternative choices international students would make due to restrictive immigration policies in any one country. The findings from this paper show that international students are responsive to comparative immigration policies in peer countries when making education investment decisions – when the U.K. implemented a more restrictive policy, some international students who would have chosen to attend universities in the U.K. instead chose to attend universities in the U.S. This provides insight into the determinants of the human capital investment decision-making process of this particular population, and demonstrates the importance of studying immigration policies in a comparative framework.

Within the immigration literature, this paper also relates to existing research on the effect of international students on domestic students. Existing research has produced conflicting results, but most rely solely on university fixed effect regression models to account for potential endogeneity bias (Borjas, 2004; Regets, 2007; Zhang, 2009). One recent paper improves upon the previous identification strategy by using an instrumental variable design. Shih (2017) uses the boom and bust in international matriculation into U.S. universities at the graduate level during the 1995-2005 period. The author uses the rising college-age populations in different countries as a predictor for international enrollment in the U.S. for the period before 9/11, and the reduction in student visa issuance for the period after 9/11. He finds that an increase in foreign graduate students increases domestic graduate enrollment at the university level possibly through cross-subsidization of tuition.[2]

Building on Shih (2017), this paper makes several contributions. First, I use administrative data that contain the universe of international student records in the U.S. and

[2]Currently, there is another working paper ((Chen, 2021)) that examines the effect of international undergraduate students in the U.S. on public university outcomes using a traditional shift-share design. Although the paper also uses U.S. administrative international student data, the analyses in the paper are at the school level, similar to Shih (2017), essentially comparing schools with larger international undergraduate student increases to schools with smaller international undergraduate student increases.

examine outcomes as recent as 2019, while Shih (2017) examines a much smaller subset of universities from nearly two decades ago. Since then, the number of international students in the U.S. has doubled in size and the global immigration policy landscape for international student population has changed drastically, which makes findings from this paper more relevant to inform current and future policymaking. The administrative data also allow me to conduct analyses at the program level, which improves upon prior university-level analyses by exploring within-school variation over time. Second, I improve upon prior identification strategies by leveraging an immigration policy shock in another top international student destination country to instrument for new international enrollment, which is plausibly exogenous to outcomes of U.S. domestic students. Third, I am the first to investigate the effect of international students on domestic students across degree levels, which provides a new and important channel for cross-subsidization of higher education resources. Furthermore, I explore heterogeneous effects on domestic students by gender, race/ethnicity and university selectivity, which suggests that international students and the additional resources they bring help reduce stratification across U.S. colleges and universities.

II Conceptual Framework

Existing research on the effect of international students on domestic students has produced mixed results. While some studies find that international students crowd out domestic students due to university space constraint (Borjas, 2004; Shen, 2016), more recent studies argue that seat availability is not a problem for most programs in U.S. colleges and universities and show that more international students, at both graduate and undergraduate levels, increase domestic enrollment through cross-subsidization of tuition (Chen, 2021; Shih, 2017). In this paper, due to data limitation,[3] I focus on program-level degree completion of domestic students as the main outcome.

Evidence has shown that majority of U.S. international students at undergraduate and master's level pay full tuition (Bound et al., 2020, 2021). Thus, more international students in a university program are likely to result in more tuition revenue, which can be used to subsidize domestic students through financial aid. Shih (2017) finds that net tuition payments of U.S. citizens fall as international enrollment increases, and it is due to larger institutional aid rather than reduced tuition rates. Similarly, the increased tuition revenue from international students can be allocated to faculty hiring, new course offerings, and

[3]Currently, program-level enrollment data at U.S. universities are not available. Prior studies that examine domestic student enrollment either use enrollment at the university level, or focus exclusively on one university using administrative student data.

institutional and departmental student support services, which could also improve program quality and increase domestic student's likelihood of graduation.

The effect of international students on domestic students through the peer effect channel is more ambiguous. On the one hand, if international students are of similar or better quality as domestic students, the peer effect literature suggest that they would perhaps have no or positive effects on domestic peers (Carrell et al., 2009; Sacerdote, 2001). Alternatively, if domestic students have certain preferences over peer composition, or readjust labor market perspectives after observing the ability of foreign peers, it is possible that some domestic students would self-select out of the programs with prominent presence of international students. Anelli et al. (2017) explore the idiosyncratic variation in the share of foreign students in introductory math courses in one university and find that foreign peers decrease the probability of domestic students graduating from STEM majors. However, switching college majors is much more realistic for students at the undergraduate level, and not so much at the graduate level, especially for master's degree programs.

One important contribution of this paper, in comparison to existing research, is that this is the first paper to examine the effect of international students on domestic students across different degree levels. Specifically, because the restrictive U.K. immigration policy change induced more international students into U.S. STEM master's programs, and not bachelor's programs, the peer composition of bachelor's domestic students stay unchanged. Therefore, I am able to abstract from the peer effect channel, and isolate the role of the financial resources channel by investigating whether and to what extent the additional tuition revenue from international students spills over to other degree levels in the same field. Since in most university budget models, departments cannot keep all the tuition revenue their programs bring in to spend exclusively on students and services in their own department/field, the results from the cross-degree-level analysis in the paper are likely a lower bound of the total effect.

III U.K.-U.S. Comparative Immigration Policies and International Students

One way to attract more international students to study in a country is through post-graduation work visa policies (Beine et al., 2023). Generally, these policies allow international students to live and work in the country of study for a certain period of time after graduation without seeking official employer sponsorship. In recent years, several top international student host countries, such as the U.S., Canada, and Australia, have implemented more

generous post-graduation visa policies. On the contrary, the U.K. has introduced a more restrictive immigration policy change that directly impacted international students. In this section, I provide more background information on post-graduation visa policies in the U.K. and the U.S. See Appendix A.1 for post-graduation visa policies in other top host countries and their comparisons.

III.1 U.K. Tier 1 (Post-Study Work)

The U.K. first introduced an early version of the Tier 1 (Post-Study Work) program in 2004, allowing non-European Union international students who graduated with a STEM degree to work in the country for 12 months without additional employer sponsorship. The program was expanded to include post-secondary degrees in all subjects in 2006, and later was replaced by Tier 1 (Post-Study Work) in 2008. Under the Tier 1 (Post-Study Work) program, international students from non-EU countries were allowed to stay and work in the U.K. for up to two years after graduating with a post-secondary degree without a need of an employer sponsorship.[4]

Since the 2010 general election, the Conservative Party targeted to reduce net migration to the U.K. from "hundreds of thousands" to "tens of thousands" by 2015 by implementing stricter immigration policies for non-EU international students, family members, and workers. In March 2011, then Home Secretary Theresa May announced that the Tier 1 (Post-Study Work) visa program would be closed starting April 2012, claiming that the program was "far too generous." After the policy change, non-EU international students can stay for two months if their program is 6 to 12 months in length, and four months if their program is 12 months or longer in length, after graduation and search for work sponsorship if they want to work in the country.

Figure I shows the number of Tier 1 (Post-Study Work) visas granted and Tier 2 (General) visas granted to previous students from 2008 to 2014. In 2011, the year before the policy change went into effect, over 40,000 international students were granted a Tier 1 (Post-Study Work) visa to stay and work in the U.K., whereas in 2013, the first full year after the policy change, only about 4,000 non-EU international students successfully obtained a Tier 2 work visa. The number stays relatively flat throughout the following years, and well below the number of previous Tier 1 (Post-Study Work) visa granting level. This illustrates the effectiveness of the immigration policy change on restricting international students from staying in the country after graduation.

[4]The Tier 1 (Post-Study Work) program was non-renewable. After the two-year period, individuals could switch to a Tier 2 visa with a job offer from an eligible employer with a sponsorship license. Tier 2 visa is for high-skilled workers, similar to the H-1B visa program in the U.S.

III.2 U.S. Optional Practical Training (OPT)

The Immigration and Nationality Act of 1952 establishes the F-1 non-immigrant visa for individuals coming to the U.S. to study temporarily. Once the study and any authorized practical training are completed, F-1 students must leave the country within 60 days, unless their period of authorized stay in the U.S. is legally extended. F-1 students generally are not authorized to work (off-campus) in the U.S. during their study. However, F-1 students are eligible to apply through the Optional Practical Training program (OPT) to work for an employer in a job directly related to their major area of study. Students may obtain OPT either during their educational program (pre-completion OPT) or after they graduate (post-completion OPT). OPT is a type of temporary work permission available for international students who have completed or have been pursuing their degrees for more than three months. Before 2008, every eligible international student is granted 12 months of regular OPT for each degree level to work in their field of study (i.e., a student may have 12 months for a bachelor's degree and another 12 months for a master's degree). On April 2, 2008, the U.S. Department of Homeland Security (DHS) announced a 17-month extension to the OPT for students in qualifying STEM fields, after which, international students with STEM degrees are eligible to stay and work in the country for up to 29 months without employer sponsorship.[5]

Many employers who hire F-1 students under OPT eventually file a petition for an H-1B visa. The H-1B visa program is for high-skilled foreign workers with at least a bachelor's degree. Congress sets a cap of H-1B visas at 65,000 for each fiscal year, with an additional 20,000 reserved for those with graduate degrees. If the number of applications exceeds the cap, which has been the case in recent years, a lottery is conducted. Unlike the H-1B visa program, the OPT program does not have an annual cap. STEM students who are on extended OPT can be entered into the H1-B visa lottery by their employer every year if they are not selected in the previous lottery, which significantly increases the chance of being selected.[6]

[5]On May 29, 2008, the Immigration Reform Law Institute filed a lawsuit in federal court challenging the validity of the 17-month OPT extension and was rejected by a New Jersey district court judge. A similar lawsuit in November 2014 challenging the STEM OPT extension was successful, with the court giving the U.S. government up to February 12, 2016 to formulate new rules. The deadline was subsequently extended by three months. On March 11, 2016, DHS published the final rule allowing F-1 international students who receive STEM degrees to apply for a 24-month OPT extension, giving STEM graduates a total of 36 months of OPT.

[6]See a detailed description of transition paths for international students under current U.S. immigration system in Bound et al. (2021).

III.3 Trends of New International Students

During the 2003-2015 period, about 40 percent of international students in the world are concentrated in four English-speaking countries: the U.S., the U.K., Canada, and Australia. Among the four countries, the U.S. has the most international students in all years, with about 20 percent of the global international student population; while the U.K. has been number two with about 10 percent. Figure II shows the number of new international students in each of the four top host countries from 2006 to 2015.[7] It shows that immediately after the cancellation of the Tier 1 (Post-Study Work) program in the U.K., the level of new international students starts to flatten out, compared with other countries, and the trend persists for the following years.

In order to zoom in on the group of students who are influenced by the U.K. policy change the most, I examine the number of new international students in the U.K. by country of origin. Figure III breaks the number of new international students down by degree level and home country's former British colonial status. The policy change was announced during the 2010/11 academic year, and it is clear that students from former British colonies in master's degree programs are the most responsive to the policy change – the number of new students in this group drops from about 50,000 before the announcement to about 30,000 by 2015/16 academic year. The enrollment trend for students from former British colonies in bachelor's degree programs also flattens after 2011. In contrast, students from non-former British colonies were less affected, especially those in master's degree programs.[8] These general patterns suggest that students might be impacted differently by the U.K. policy change depending on their home country's former British colonial status.

The difference in the enrollment patterns by home country's colonial status is intuitive. Before 2012, the U.S. and the U.K. had relatively similar post-graduation visa policies for international students, especially for those with STEM degrees (29 months in the U.S. vs. 24 months in the U.K.). But for most students from former British colonies, the U.K. could have been their first choice based on familiarity with the education system and potential existing network connections. Once the U.K. cancelled the post-graduation visa program, the potential benefit of studying in a more familiar country might be outweighed by the

[7]For Canada, the exact count of new international students by level of study is not available for all years. In recent years, about 75-80 percent of all international students in Canada are at the post-secondary level. Thus, I multiple the total number of new international students in each year by 0.75 and arrive at the level in Figure II.

[8]The dip for bachelor's degree students from non-former British colonial countries around the 2012/13 academic year is likely driven by EU students from another policy change in the U.K. Before 2012, universities in England could charge tuition fees of around £3,000 to domestic and EU students. The cap was raised to £9,000 and went into effect in September 2012. Figure D1 in the Appendix plots the number of students from EU/EEA countries in the U.K. over time and confirms this hypothesis.

potential cost of not being able to gain work experience. Thus, students from former British colonies showed a much stronger response to the U.K. policy change, compared to those from other countries, for whom the U.S. could have been the first choice regardless of the U.K. immigration policy. My identification strategy directly exploits the different responsiveness to the U.K. policy change by student's country of origin.

IV Data

IV.1 Data Sources and Sample Restriction

I obtained administrative data on U.S. international students from the U.S. Immigration and Customs Enforcement (ICE) through a FOIA request. To my knowledge, this dataset has never been used before in analyses of international student effects on domestic students. The individual-level data contain all new international students in the U.S. from 2003 to 2015. The data are extremely rich and include not only each student's gender, age, country of citizenship, school name, school address, primary major of study, degree level, program start and end dates, and first-year cost of attendance, but also each student's first-year funding sources and exact funding amount from each source. The funding information allows me to test the mechanism of international student effects on university finances. The list of STEM degree programs also comes from ICE. The degree programs are categorized using the six-digit Classification of Instructional Programs (CIP) code.[9]

I supplement the ICE data on international student enrollment with institution-level data of U.S. universities from the Integrated Postsecondary Education Data System (IPEDS). IPEDS data contain institutional characteristics, university finances, as well as the number of degree awards by students' gender, race/ethnicity, immigration status (nonresident alien), degree level, and major (six-digit CIP code level) each year. I construct the number of domestic degree completion by subtracting the number of nonresident alien degree completion from the number of total degree completion.

The country-level historical colonial link data come from CEPII's GeoDist dataset. I categorize an international student's home country as a former British colonial country if Great Britain has colonized the home country for a relatively long period of time and with

[9]DHS published a list of 328 qualifying STEM programs in 2008. The broad STEM categories include animal sciences, plant sciences, soil sciences, natural resources; computer and information sciences; engineering, engineering technologies; biological and biomedical sciences; mathematics and statistics; military technologies; physical sciences; science technologies/technicians; and psychology. On May 11, 2012, DHS added more programs to the STEM list, including environmental studies, architectural and building sciences, behavioral sciences, archaeology, and veterinary programs. For all analyses in this paper, I use the 2012 STEM list to categorize university degree programs.

a substantial participation in the governance of the home country.[10] In the analysis sample, U.S. international students come from 233 countries, out of which 75 are former British colonial countries[11].

Finally, for the main analyses, I collapse the individual-level international student data to the school-major-degree level and merge it with IPEDS program-level (school-major-degree) completion data for each year. Since the IPEDS completion data are reported using the July 1-June 30 window, i.e., degree completions for year 2015 contain the number of completions between July 1, 2014 to June 30, 2015, I adjust the year variable based on program start dates in the international student data to make the time period consistent between the two datasets. Furthermore, I exclude all programs in the international student data where no domestic students completed in a given year; this is to avoid potential fraudulent programs that target international students and exploit student visa loopholes (Bartlett et al., 2011). In addition, I include only institutions that offer bachelor's degrees or more and have at least 1 international student during the 2003-2015 period. The final analysis sample consists of 82,098 unique programs in 61,548 unique majors from 2,353 unique schools across 13 years.

IV.2 Descriptive Statistics

Figure IV shows the trends of new international student enrollment by degree level and STEM status. Overall, all degree levels have seen an increase of international student enrollment over the analysis period. The increases are more moderate for doctorate degrees, for both STEM and non-STEM programs, compared with the increases for bachelor's and master's degrees. The most dramatic increase, however, is seen from the master's STEM programs after 2013.[12] By 2015, the number of new international students in STEM master's programs has surpassed that of non-STEM bachelor's programs for the first time.[13] Since in the administrative international student data I do not observe whether an international student completes a program, I examine the number of completions of international students (non-resident aliens) using the IPEDS data (see Figure D3 in the Appendix). The completion trends and magnitudes correspond to the enrollment data, which suggest that most

[10] See Mayer and Zignago (2011) for detailed notes on the dataset.

[11] See the list of international students' home countries that are former British colonies in Table C1 in the Appendix.

[12] Since the U.K. announced the immigration policy change in March 2011, the earliest possible time that students could apply to U.S. programs was fall of 2011 (academic year 2012), and the earliest for students to enroll in U.S. programs is fall of 2012 (academic year 2013). Thus, the earliest possible period that the U.K. immigration policy could affect U.S. international enrollment was 2013.

[13] Table C2 in the Appendix shows the top-25 STEM master's programs in terms of the increase in average number of new international students after 2012. Over half of the programs on the list come from public four-year institutions and the most common programs are variations of computer science, electrical and electronics engineering, and information science and technology.

international students finish the programs they start.

In order to explore the relationship between colonial ties to the U.K. and responsiveness to the policy change in the U.K., I examine the trends of new international students by home countries' former British colonial status. Figure V shows the new international enrollment at U.S. universities by degree level and STEM status, separately for students from countries without and with colonial links to the U.K. For students from countries without colonial ties to the U.K., trends for new international enrollment in STEM and non-STEM programs are parallel for each degree level, before and after the U.K. policy change. However, when examining the new international enrollment for those from former British colonial countries, we see a clear trend break: After 2013, there is a surge of new international students in STEM master's programs, as well as a slight uptick in STEM bachelor's programs, compared to the trajectory of their non-STEM counterparts. These patterns suggest that students from countries with colonial ties to the U.K. are the group that is most responsive to, or most "treated" by the U.K. policy change in 2012. This feature of the policy change forms the basis of my empirical strategy, which is explained in the next section.[14]

Figure VI shows the new international student funding trends by degree level and STEM status. Funding trends for associate and doctorate degrees for both STEM and non-STEM programs have stayed relatively stable over the time period. However, there is a visible increase in the percentage of new international students in STEM Master's programs who receive no institutional aid over the years. In early 2000s, about 70 percent of new international students in STEM Master's programs receive no institutional aid; by 2015, that number increases to about 85 percent. Together with the dramatic surge of the number of new international students in STEM Master's programs post-2013, the increase of the total amount of tuition paid to schools is large.

Finally, Table I shows the descriptive statistics of the average number of domestic completions and international enrollment at the school-major-degree-year level, and separately by program's STEM status. Between 2003 and 2015, on average, 31.86 domestic students complete from a given program each year, among which 14.16 are men and 17.7 are women, consistent with the recent trend of college enrollment by gender. About two thirds of the degree completions come from whites, which are about seven times of those from Blacks, Hispanics, and Asians. For program-level enrollment, on average, there are 3.92 new international students enrolled in a given program each year, and among them, 34 percent

[14]Since students from the U.K. and EU/EEA countries were not affected by the U.K. immigration policy change, the enrollment trend of this group in the U.S. is not expected to change around the time of the policy change. Figure D4 in the Appendix plots the number of new international students by UK/EU/EEA country status over time, which shows that the increase of enrollment after the U.K. policy change is driven entirely by students from outside UK/EU/EEA countries.

are students from former British colonies. Majority of domestic students complete with a non-STEM degree. This pattern is more pronounced for domestic women than men – for domestic men, the ratio of non-STEM to STEM completion is close to 1.5:1, whereas for domestic women, this ratio is close to 4:1. This gender disparity in STEM holds for white, black, and Hispanic domestic students, and is less pronounced for Asian domestic students. However, more international students enroll in and complete with a STEM degree than a non-STEM degree. And students from former British colonies account for close to 40 percent of international students in STEM programs.

V Effect of U.K. Immigration Policy Change on New International Enrollment in the U.S.

V.1 Empirical Strategy

I use the changes in new international enrollment in U.S. universities induced by the 2012 U.K. immigration policy change to determine the causal impact of international students on U.S. domestic students and university finances. First, I implement a triple difference research design and estimate how new international enrollment in U.S. universities changes among students from former British colonial countries in STEM programs relative to those in non-STEM programs, in response to the U.K. immigration policy change in 2012, and how this change relates to the change in new international enrollment for students from countries without colonial ties to the U.K whose programs differ in STEM status.

I employ this strategy for two reasons. First, since the U.S. post-graduation visa policy offers drastically different lengths for students with STEM degrees (29 months) and those with non-STEM degrees (12 months), using new international enrollment in non-STEM programs as a control group accounts for the overall trend of attractiveness of U.S. universities to foreign students regardless of post-graduation visa benefits. Second, since students from former British colonial countries responded to the U.K. immigration policy change differently, using students from other countries in the same program as the control group accounts for potential program-specific changes that affect both international and domestic students. For this analysis, I estimate regressions of the following form:

$$\begin{aligned} International_{omdst} = \beta_0 &+ \beta_1 STEM_m \times Post_t \times Colonial_o + \beta_2 Colonial_o \\ &+ \beta_3 STEM_m \times Post_t + \beta_4 STEM_m \times Colonial_o + \beta_5 Post_t \times Colonial_o \\ &+ \alpha_{dt} + \delta_{st} + \gamma_{sm} + \epsilon_{omdst}, \end{aligned} \tag{1}$$

where $International_{omdst}$ is the number of new international students from country of origin o, in major m, at degree level d, in school s, in year t. $STEM_m$, $Post_t$, and $Colonial_o$ are all dummy variables that equal to 1 if major m is categorized as STEM, year t is after 2012, the year the U.K. policy change went into effect, and country of origin o is a former British colonial country. The variables α_{dt}, δ_{st}, and γ_{sm} are degree by year, school by year, and school by major fixed effects, respectively[15]. Standard errors are two-way clustered at the school and major level. Conceptually, equation (1) should also include each of and two-way interactions between $STEM_m$, $Post_t$, and $Colonial_o$; but since $STEM_m$ and $Post_t$ are absorbed by major by year fixed effects, the terms are omitted in the equation.

The coefficient, β_1, is the estimate of the causal effect of the U.K. immigration policy change on new international student enrollment in U.S. university programs. In order for the effect to be causal, two conditions need to be met. First, the parallel trend assumption needs to be satisfied. That is, in the absence of the U.K. immigration policy change, international student enrollment patterns in U.S. STEM and non-STEM programs for students from both former British colonial countries and other countries need to trend similarly over time. Second, there needs not to be shocks that affect enrollment around the time of the treatment differently for STEM students coming from former British colonial countries. For the first condition, visually, from the raw plots in Figure V, the parallel trends hold; nevertheless, I formally test this assumption using the standard event study analysis techniques. Since it is not straightforward to illustrate for a triple difference specification, I reduce the event study analysis to a standard difference-in-differences design that compares new international student enrollment in STEM programs to that in non-STEM programs, before and after 2012. I separately estimate the model for students from former British colonial countries and those from other countries. For the event study analysis, I estimate the following regression:

$$International_{mdst} = \beta_0 + \sum_{t=2003, t\neq 2012}^{2015} \phi_t STEM_m \times t + \alpha_{dt} + \delta_{st} + \gamma_{sm} + \epsilon_{mdst} \qquad (2)$$

To illustrate the event studies graphically, I plot each ϕ_t on the y-axis against year on the x-axis. This creates a visual representation of the difference in pre-treatment trends of new international enrollment in STEM and non-STEM programs. Year 2012 is excluded from the analysis so that all regression coefficients are relative to 2012, the year immediately preceding the U.K. immigration policy change.

Figure VII presents the event studies of the effect of the U.K. immigration policy change on total new international enrollment in the U.S. from non-former British colonial countries

[15]The inclusion of major by year fixed effects soaks up most of the remaining variation, thus is excluded from the specifications.

and former British colonial countries, respectively. The figures are set to the same scale. It is clear that for both groups there is no pre-trend in new enrollment in the U.S. prior to the U.K. policy change. I create separate event study figures for each degree level and by home countries' former British colonial status (Figures D5-D10 in the Appendix), and the parallel trends largely hold for all degree levels.

In addition to the parallel trend assumption, in order for β_1 from equation (1) to produce a causal estimate of the effect of the U.K. policy change, it must also be the case that there are no other group-specific shocks that affect enrollment of STEM students from former British colonies around the time of the treatment. The specification in equation (1) includes degree-by-year, school-by-year, and school-by-major fixed effects. Thus, in order for this to be a concern, there needs to be within-school and program time-variant unobserved shocks to STEM programs around 2012 that directly affect enrollment decision of international students, and these unobserved shocks need to affect students from former British colonial countries and students from other countries differently. Even if certain programs within STEM improved program quality and became more attractive to students around 2012, the interaction with home countries' colonial status would net out this common shock and only compare changes in international enrollment in the same program in the same year by home countries' colonial status. Therefore, the triple difference design in equation (1) is likely to produce the causal effect of the U.K. immigration policy change on new international enrollment in U.S. universities.

V.2 Triple Difference Results

Table II shows the results from the triple difference models from equation (1). The point estimates for $STEM \times Post \times Colonial$ are the causal effect of the U.K. immigration policy change on new international student enrollment in the U.S. Overall, the more restrictive U.K. policy change increases the number of new international students from former British colonial countries in U.S. STEM programs by 0.732 and the estimate is statistically significant at the 5 percent level. This is an over 40 percent increase based on the average number of international students from former British colonies in STEM programs (see Table I). Additionally, when examining further at the heterogeneous effects by degree level in columns (2)-(5), the increase of new international student enrollment in the U.S. is entirely driven by new enrollment in master's programs. On average, the U.K. policy change increases the number of new international students from former British colonial countries in STEM Master's programs in the U.S. by 2.661. The estimate is statistically significant at the 1 percent level. At the same time, the U.K. policy change has no effect on new enrollment in associate's and bachelor's

STEM programs and has significant negative effect on new enrollment in doctorate STEM programs for students from former British colonial countries. These results are consistent with the raw trends shown in Figure V, and are intuitive to explain. On the one hand, it is highly unlikely for international students to know about the details and benefits of post-graduation visa policies before starting college education since they are relatively young and the prospect of post-graduation plans is highly uncertain. Thus, any significant effect of the U.K. immigration policy change on new international enrollment in U.S. associate's and bachelor's programs is not expected. On the other hand, many STEM master's programs in the U.S. are relatively short (1-2 years), so if the goal is to utilize the STEM OPT to gain work experience, investing in a STEM master's program would have the highest return. The results also show that there is a small but statistically significant decrease in the number of new colonial international students in STEM doctorate programs after the U.K. immigration policy change. It could be that the increase in popularity of STEM master's programs within the former British colonial international student population changed the mind of some colonial students who intended to pursue doctorate degrees.

Columns (6) and (7) in Table II show the effect of the U.K. policy change on new international enrollment in the U.S. by institutional type. Overall, there is an increase of 0.986 international students from former British colonial countries in STEM program in public four-year universities in the U.S. The point estimate is statistically significant at the 1 percent level. On the contrary, the effect on private not-for-profit four-year schools is positive, but not significant, and the point estimate is much smaller than the point estimate in public four-year universities. This is consistent with findings from recent studies that public universities are more likely to seek out international students for budgetary reasons (Bound et al., 2020; Shih, 2017).

VI Effect of International Enrollment on Domestic Completion

The biggest challenge of estimating the causal effect of new international student enrollment on domestic students' degree completion is endogeneity of the foreign student share. Factors such as time-varying university quality, popularity, and program-specific characteristics are likely to influence both international enrollment and domestic completion. Therefore, a naive OLS regression that regresses domestic completion on international enrollment would most certainly suffer from omitted variable bias. To overcome this identification challenge, I employ an instrumental variable (IV) identification strategy that exploits the increase in

international students from the U.K. policy change discussed in the prior section.

VI.1 IV Strategy

To estimate the causal effect of international students on domestic students, I use an instrumental variable (IV) design and leverage the change in new international enrollment induced only by the U.K. policy change. Specifically, I create an instrument for new U.S. international enrollment at the program-year level (school-degree-major-year) to examine the effect of new international student enrollment on U.S. domestic college completion.[16] I estimate regressions of the following form:

$$Domestic_{mdst} = \beta_0 + \beta_1 International_{mdst} + \alpha_{dt} + \delta_{st} + \gamma_{sm} + \epsilon_{mdst}, \tag{3}$$

where $Domestic_{mdst}$ is the number of domestic student completions from major m, in degree level d, from school s, in year t. $International_{mdst}$ is the number of new international students in major m, in degree level d, from school s, in year t that is instrumented using the IV. Similar to equation (1), α_{dt}, δ_{st}, and γ_{sm} are degree-by-year, school-by-year, and school-by-major fixed effects, respectively. Standard errors are two-way clustered at the school and program level.

Intuitively, the number of new international students at the program level is the sum of two elements – those who come from former British colonial countries and those who come from other countries. For the number of new international students from former British colonies, I construct a measure where the predicted number of colonial students from the triple-difference specification from equation (1), which is driven by the U.K. immigration policy change, is weighted by the baseline exposure of a university major to students from former British colonies. The number of new international students from non-colonial countries is measured using the average number during the baseline years. Formally, the instrument is constructed using the following equations:

$$\widetilde{International}_{mdst} = \frac{ColonialShare^{ms}_{2003-2010}}{AverageColonialShare_{2003-2010}} \times \widehat{Colonial}_{mdst} + Non-Colonial^{ms}_{2003-2010} \tag{4}$$

where

$$ColonialShare^{ms}_{2003-2010} = \frac{Colonial^{ms}_{2003-2010}}{International^{ms}_{2003-2010}} \tag{5}$$

[16] IPEDS data only have number of degree completions available at the six-digit CIP code level. Enrollment data, however, are only available at the school level. Thus, the main outcomes in this paper are U.S. domestic student degree completions.

$$\widehat{Colonial}_{mdst} = \widehat{International}_{omdst}, \text{ for } Colonial_o = 1 \quad (6)$$

$\widetilde{International}_{mdst}$ is the predicted number of new international students in major m, in degree level d, from school s, in year t. The term, $\frac{ColonialShare^{ms}_{2003-2010}}{AverageColonialShare_{2003-2010}}$, is the ratio of the share of students from former British colonial countries in major m from school s during baseline years 2003-2010 ($ColonialShare^{ms}_{2003-2010}$) to the average share of colonial international students across all programs during baseline years ($AverageColonialShare_{2003-2010}$). This measures the baseline prominence of students from former British colonial countries among all international students for a given school-major and serves as a measure of treatment intensity. The share of colonial international students of a given school-major ($ColonialShare^{ms}_{2003-2010}$) is specified in equation (5), which is the total number of colonial international students as a share of total number of all international students in major m from school s during baseline years 2003 and 2010. The term $\widehat{Colonial}_{mdst}$ is the number of students from former British colonial countries in major m, in degree level d, from school s, in year t, which is predicted from equation (1). $Non-Colonial^{ms}_{2003-2010}$ measures the average number of international students from non-former-British colonial countries in major m in school s in the baseline years 2003-2010, before the U.K. immigration policy change. Using the average number of non-colonial students from pre-period excludes the potential endogenous growth of this group after the U.K. policy change.

The validity of the instrument relies on two assumptions – relevance and exclusion restriction. Relevance requires that the predicted number of international students in a university degree program to be strongly correlated with the actual number of international students. Table III shows the strength of the first-stage IV. Column (1) uses the full sample, columns (2)-(5) break the sample down by degree level, and columns (6) and (7) separate universities by type. Overall, the instrument is a strong predictor of the number of international students in a given university degree program, and especially for master's programs and in public 4-year universities. Consistent with the triple difference results from Table II, the instrument is weak for associate's, bachelor's, and doctorate degree levels, as well as private not-for-profit universities. Thus, the 2SLS results will only be shown for the subgroups with a strong enough first-stage to be informative. This also informs the analyses below where I exclusively exam the cross-degree effect of international students in master's degree programs on domestic students in other degree levels.

The first-stage strength can also be seen visually. Figure VIII plots actual international student enrollment within university degree programs against the instrument, after partialling out degree by year, school by year, and school by major fixed effects. If the actual international student enrollment changes only as a result of the U.K. immigration

policy change, the fitted line and the 45 degree line would coincide. However, the fitted line is steeper, which indicates that, on average, the actual international enrollment grows faster within university degree programs than it would have if the U.K. immigration policy change were the only contributing factor.

The second assumption for a valid instrument is the satisfaction of the exclusion restriction. Specifically, the instrument must only affect new international student enrollment in the U.S. and not relate to other determinants of U.S. domestic student college completion. Since the instrument is largely constructed using the immigration policy change in the U.K. that disproportionately affects international students from former British colonial countries in STEM programs, and the U.K. immigration policy change was almost certainly not made in response to U.S. domestic college students or university performance, it is highly unlikely that the exclusion restriction will be violated. Using an exogenous policy shock as the shifter provides shocks that are arguably as-good-as randomly assigned conditional on observables and fixed effects. This improves upon the existing immigration literature that heavily replies on traditional shift-share IVs that do not use policy-driven immigration shifts.

VI.2 2SLS Main Results

Table IV presents the baseline two-stage-least-square results of the effect of overall international enrollment on domestic student college completion using the IV strategy. Since the change in new international student enrollment is not likely to affect domestic student degree completion in the same year, I explore the sensitivity to time lag assumptions and estimate the model using domestic completion in the current year as well as domestic completion 1-4 years in the future. Note that all estimates from Table IV represent the average effect of new international enrollment on domestic completion at the same degree level (i.e., the effect of new international enrollment in master's programs on domestic completion in master's programs, etc.). Column (1) shows the OLS result for comparison. Column (2) shows the overall effect of one additional international student on domestic completion. The effect size becomes larger and statistically significant over time. On average, one additional international student increases domestic student degree completion by 0.691 four years later. The magnitude of the effect is largely in line with recent literature that finds one additional international graduate student increases domestic graduate student enrollment by 0.8 (Shih, 2017). And since the outcome I focus on is degree completion, it is reasonable to expect a slightly smaller effect size to account for dropouts.

I then separate the sample by degree level and school type. Note that since the first-stage instrument is only strong for certain sub-groups, the results are only shown for master's

degree, public four-year universities overall, public master's degree, and selective public universities. The result suggests that one additional new international student enrolled in a master's degree program leads to a 0.0988 increase in domestic completion in the same program four years later. This effect is marginally significant at the 10 percent level. This finding is plausible because most universities do not offer much financial aid to domestic students in master's programs, thus it is unclear the channel through which international enrollment can affect domestic completion. This further suggests the necessity to investigate cross-degree level effects. On the other hand, the effect on public four-year universities is highly significant and the effect size is larger compared to the overall effect in column (2). On average, one additional new international student leads to 1.115 more domestic student completions four years later. The effect size is large but plausible – since international students pay 2-3 times the in-state tuition at public universities, the amount of tuition paid by one international student could theoretically subsidize multiple domestic in-state students. The results for public master's degree and selective public universities are largely mimicking the overall master's degree and overall public universities, respectively, with smaller magnitude.[17]

In addition to examining the effect at the same degree level, I provide, to my knowledge, the first cross-degree level estimates of the international student impact on U.S. domestic students. This is important because many university departments spend revenues from master's programs on tuition assistance and program improvement for other degree levels. Table V presents the results of the effect of new international student enrollment in master's programs on domestic student completion in other degree level programs in the same field. Similar to Table IV, I show the overall effect and separately examine effects by degree levels and school type. On average, one additional international student enrolled in a master's program leads to a 0.243 increase in domestic student completion four years later. Interestingly, the result is largely driven by domestic completion in bachelor's degree programs. One additional new international master's student, on average, leads to an increase of 0.633 domestic bachelor's degree completion four years later. This is consistent with the cross-degree resource sharing strategy that is practiced by many U.S. universities. Schools use the master's programs to bring in revenues and spend them, in part, to support domestic students in bachelor's degree programs. When examining by school type, we observe positive and significant effects for both public four-year universities and highly-selective public universities.

[17] A recent methodological paper by Lee et al. (2022) points out that the conventional threshold of first-stage F statistics of 10, in many cases, yields an anti-conservative test. The authors propose a tF procedure that provides F-dependent adjusted t-ratio critical values. I re-examine the significance of my main results based on the 5% t-values. The total effect and effect for public four-year institutions remain statistically significant at the 5% level.

I also explore an alternative IV strategy to solidify the main findings. The details of the alternative specifications and results are shown in Appendix B. Specifically, I estimate a triple difference with treatment intensity measured by the baseline program-level exposure to colonial students in the first step. Then, I instrument new international enrollment directly using the triple interaction term $STEM * Post * Ratio$ in the 2SLS specification to estimate the effect of international enrollment on domestic completion. Results under the alternative IV strategy are consistent with the results in the main specification qualitatively, but with larger magnitude. This suggests that the main findings in the paper, if anything, are likely to be the conservative estimates of the resource effects of international students on domestic completion.

VI.3 Heterogeneous Effects

I explore the heterogeneous treatment effect of international students in master's degree programs on different subgroups of domestic students in bachelor's degree programs. Table VI shows the results by domestic students' gender and race/ethnicity. Column (1), as a reference point, is the same as column (3) in Table V. The positive and significant effect of master's international students only applies to male domestic students and not female domestic students. On average, one additional master's international student leads to an increase of 0.488 bachelor's degree completions for male domestic students four years later. When examining the effect by race/ethnicity, it appears that the positive effect of master's international enrollment leads to increase in domestic bachelor's completion for whites, blacks, and Asians, with white students having the largest effect size – an increase in one international student, on average, increases white domestic student completions four years later by 0.42. This accounts for about two thirds of the total effect size. But given the fact that whites account for about two thirds of the total degree completions in a given program in a given year during the sample period, this effect size is reasonable. As expected, black and Asian domestic completions are positively affected in much smaller magnitudes.

I also explore the potential heterogeneous treatment effects by college selectivity tier. Following Chetty et al. (2017), I categorize four-year universities into eight tiers based on Barron's 2009 index (Barron's Educational Series, 2008) and university sector (public vs. private) – Ivy Plus (the Ivy League plus Stanford, MIT, Chicago, and Duke), other elite (Barron's Tier 1 excluding the Ivy Plus; 68 colleges in the analysis sample), highly selective public (Barron's Tier 2 and public; 61 colleges), highly selective private (Barron's Tier 2 and private not-for-profit; 77 colleges), selective public (Barron's Tiers 3-5 and public; 450 colleges), selective private (Barron's Tiers 3-5 and private not-for-profit; 636 colleges), non-

selective public (Barron's Tier 9 and all public four-year colleges not included in the Barron's selectivity index; 75 colleges), and non-selective private (Barron's Tier 9 and all private not-for-profit four-year colleges not included in the Barron's selectivity index; 186 colleges).

Results by college selectivity tier are shown in the Appendix. Table C4 shows the effect of the U.K. immigration policy change on new international enrollment in the U.S. from the triple-difference specification from equation (1). Overall, the statistically significant and positive effect is concentrated in selective public and selective private colleges. After the U.K. immigration policy change, a program in selective public four-year colleges sees, on average, an increase of 1.2 new international students. The coefficient for highly selective public colleges is also positive but not statistically significant. Column (6) of Table IV and columns (6) and (7) from Table V show the effect of international student on U.S. domestic student college completion from the 2SLS specifications. Again, the effect is concentrated in highly selective and selective public four-year universities.

Taken together, selective public universities see the largest inflow of international students from former British colonial countries as a result of the U.K. immigration policy change, and those universities also see the largest positive effect from the international student inflow on college completion of U.S. domestic students. This is consistent with the main results from the previous section and suggests that cross-subsidization of tuition fees could be a main channel.

VI.4 Effects on University Finances

The analyses above are all at the program level, however, many university finance related outcomes are not available at the program level in the IPEDS data. Therefore, I collapse the program-level data to institution-year level and estimate the effect of international enrollment on U.S. university finances, such as instructional spending, research and academic support expenses, and financial aid. I estimate regressions of the following form:

$$Finance_{st} = \beta_0 + \beta_1 International_{st} + \alpha_s + \delta_t + \epsilon_{st}, \tag{7}$$

where $Finance_{mdst}$ is a set of university finance outcomes of school s, in year t. $International_{st}$ is the instrumented number of new international students in school s, in year t, which is the sum of the program-level predicted number of new international students from equations (4)-(6). The variables α_s and δ_t are school and year fixed effects, respectively. Standard errors are clustered at the school level.

Table VII shows the results for institutional financial aid related outcomes. Overall, new international enrollment has positive and significant effects on both the number of

institutional grant aid and the average grant aid amount to first-time degree-seeking undergraduate students. The total student financial aid amount and the amount of discounts and allowances applied to tuition and fees also increase as the number of new international student increases at the school level. The effect is immediate, suggesting the immediate cross-subsidization of tuition fees from international students to domestic students. Tables C5 and C6 in the Appendix separately show the effects of new international enrollment on selected university revenue and expenditure categories. Overall, an increase in the number of new international students increases total current revenue, net tuition and fees, as well as net auxiliary enterprises revenue. At the same time, the additional revenues are spent on all major expenditure categories, leading with instruction and research, followed by academic support and student services. One caveat regarding these results is that since the outcomes are at university level, it is impossible to include more extensive fixed effects such as university-by-year and university-by-major. This means that the variations from this analysis are coming from across universities and not within university over time. Thus, the results shown in this section should be taken as suggestive evidence.

VII Mechanisms

VII.1 Program-Level Tuition Revenue

In this section, I explore the potential mechanisms of the effect of new international student enrollment on domestic student completion in the U.S. Specifically, I investigate how program-level tuition revenue from international students has changed at U.S. universities as a result of the U.K. immigration policy change. I estimate program-level regressions of the following form:

$$Tuition_{mdst} = \beta_0 + \beta_1 STEM_m \times Post_t + \alpha_{dt} + \delta_{st} + \gamma_{sm} + \epsilon_{mdst}, \tag{8}$$

where $Tuition_{mdst}$ is the amount of tuition revenue from new international students in major m, in degree level d, in school s, and in year t. I examine the program-level tuition revenue from all international students, and separately from students who come from non-former British colonial countries and those who are from former British colonial countries. Similar to equation (1), $STEM_m$ and $Post_t$ are dummy variables that equal 1 if major m is categorized as STEM, and year t is after 2012, the year the U.K. policy change went into effect. The variables α_{dt}, δ_{st}, and γ_{sm} are degree-by-year, school-by-year, and school-by-major fixed effects, respectively. Standard errors are two-way clustered at the school and program level.

The estimate of interest, β_1, shows the change in program-level tuition revenue in

STEM programs relative to non-STEM programs as a result of the U.K. immigration policy change in 2012. As explained in the Conceptual Framework section, due to the comparative immigration policy difference between the U.K. and the U.S., U.S. STEM programs are expected to be affected by the U.K. policy change, compared to non-STEM programs. I also estimate this model separately by degree level and school type.

Table VIII shows the results from equation (8), on the impact of the U.K. immigration policy change on program-level tuition revenue from international students in U.S. universities. Panel A shows that overall the total tuition revenue increases, on average, $43,060 after the U.K. policy change, although the estimates are not statistically significant. It is driven by tuition revenues from master's programs and in public four-year universities. Panel B shows the impact of the U.K. policy change on program-level tuition revenue from international students who come from non-former British colonial countries, which also serves as a falsification test. Consistent with findings from previous sections, program-level tuition revenue from students from non-former British colonial countries did not change significantly after the U.K. policy change.

Panel C shows the effect on program-level tuition revenue from former-British colonial international students. On average, there is a statistically significant increase of $36,896 in tuition revenue in a program after the U.K. policy change at the 1 percent level. The master's programs see the largest effect of $114,284, consistent with the fact that they also experience the largest increase in new international enrollment particularly from those from former-British colonial countries. Although both public and private universities experience significant effects, the effect size and significance level are much larger in public four-year universities. On average, a program receives $44,928 more in tuition revenue from new international students after the U.K. policy change.

VII.2 Effect Size

In order to assess whether the effect sizes reported above are reasonable, I conduct a series of back-of-the-envelope calculations to connect the various findings, particularly for public four-year institutions where the effects are concentrated. First, from the triple-difference estimation (Table II), I find that the U.K. immigration policy change increases the number of new international student by 0.986 students. Second, from the IV estimation (Table IV), an additional international student increases domestic completion four years later by 1.115 students. Third, from the difference-in-differences estimation on program-level tuition revenues received from international students (Table VIII), after the U.K. immigration policy change that disproportionately affected students from former British colonial countries,

programs received, on average, $44,928 more in tuition revenue from students from former British colonial countries.

Currently, the average public four-year university's tuition and fees for an in-state domestic student is about $10,000 per year. If a program provides a $10,000 scholarship for 1.115 in-state students for four years, the amount ($44,600) comes close to the tuition revenue increase from former British colonial students after the U.K. policy change ($44,928). Also note that the results from Table VIII only account for the first-year tuition revenue from only colonial international students. Though some master's programs are one year in length, many programs are longer. So the results from Table VIII should vastly underestimate the actual increase in tuition revenue from international students at the program level. This is relevant also because programs usually cannot keep all the tuition revenue; depending on the university budget model, programs under a decentralized budget model are able to keep more revenue within program or college than those under a more centralized model. This would be an interesting and important research avenue for future investigations.

VIII Conclusion

In this paper, I utilize the richness of new administrative international student data and examine the resource effect of new international student enrollment on U.S. domestic student college completion by leveraging an restrictive immigration policy change in the U.K. that induced more former British colonial international students to enroll in U.S. universities. In addition to causally estimating the overall impact on domestic college completion, I provide, to my knowledge, the first causal cross-degree level estimates of revenue-generating master's programs. I also investigate heterogeneous effects of international students on domestic students by gender, race/ethnicity, and university selectivity.

Overall, I find that the restrictive U.K. immigration policy change significantly affects students from former British colonial countries by increasing their enrollment in U.S. universities, especially in STEM master's degree programs and in public four-year universities. Furthermore, an increase in new international enrollment in the U.S. leads to about 0.7 more U.S. domestic students to complete a college degree four years later. Again, the effect is concentrated in public four-year universities. Perhaps most interestingly, I find that there is substantial cross-degree level effect: an increase in international master's student leads to about 0.6 more domestic students to complete a bachelor's degree four years later. In addition, the heterogeneous estimates show that the effect of an increase in master's international enrollment is only seen by male, white, black, and Asian bachelor's domestic students. And selective public universities benefit the most from the additional international enrollment.

Finally, I find that U.S. university programs receive substantially more tuition revenue from those from former British colonial countries after the U.K. policy change. This result echos the findings from recent literature and suggests that the main channel of the positive impact of international student on domestic students is through cross-subsidization of tuition.

This paper provides important insights into the role that international students play in U.S. higher education through resource effects. In addition to methodological and data quality improvements compared to existing research, this is the first paper that studies the international student population and its impact in a cross-country context using comparative immigration policies. The results shed more light on international students' human capital investment decision making process, and show that under a more restrictive immigration policy regime in the U.K., more international students choose to come to the U.S. where a more lenient post-graduation visa policy is offered for STEM graduates. The results also help inform potential immigration policy reforms in the U.S., especially on how to attract and retain high-skilled individuals. Currently, there are heated debates and ongoing lawsuits over whether the post-graduation work program for international students in the U.S. should be cancelled. Given the recent political climate on immigration in the U.S. that is somewhat similar to the U.K. prior to its immigration policy change in 2012, the findings from this paper could serve as a cautionary tale.

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IX Tables

Table I: Descriptive Statistics

Variable	All	STEM	Non-STEM
Average number of completions			
Domestic total	31.86	17.36	39.68
Domestic men	14.16	10.90	15.92
Domestic women	17.70	6.45	23.76
White	20.92	11.35	26.09
Black	2.82	1.07	3.77
Hispanic	2.81	1.23	3.66
Asian	2.66	2.40	2.81
American Indian	0.19	0.09	0.24
Nonresident alien	2.96	3.41	2.72
Average Enrollment			
International	3.92	4.60	3.56
Share colonial	0.34	0.39	0.31
Number of programs	82,098	25,179	56,919

Notes: Program-level (school-major-degree) completion data come from IPEDS. Administrative international enrollment data are from the U.S. Immigration and Customs Enforcement (ICE), collapsed to program level. Program's STEM and non-STEM categorization comes from the Department of Homeland Security.

Table II: Effect of U.K. Immigration Policy Change on U.S. New International Enrollment

VARIABLES	(1) Total	(2) Associate's	(3) Bachelor's	(4) Master's	(5) Doctorate	(6) Public 4-yr	(7) Private NFP
STEM*Post*Colonial	0.732**	0.617	-0.100	2.661***	-0.514***	0.986***	0.241
	(0.302)	(0.606)	(0.322)	(0.895)	(0.127)	(0.377)	(0.353)
STEM*Post	0.258	-1.055	0.251	0.423	0.311***	0.278	0.292
	(0.320)	(1.172)	(0.407)	(0.542)	(0.118)	(0.333)	(0.384)
STEM*Colonial	0.950***	1.740***	0.542**	2.809***	-0.893***	0.927***	0.912***
	(0.316)	(0.493)	(0.270)	(0.728)	(0.289)	(0.340)	(0.319)
Post*Colonial	-1.433***	-1.260**	-1.524***	-1.786***	-0.144**	-1.479***	-1.389***
	(0.190)	(0.628)	(0.251)	(0.301)	(0.0709)	(0.245)	(0.204)
Colonial	-1.417***	-2.002***	-1.334***	-1.729***	-0.895***	-1.396***	-1.394***
	(0.280)	(0.511)	(0.260)	(0.419)	(0.170)	(0.292)	(0.299)
School by year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School by program FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Degree by year FE	Yes	No	No	No	No	Yes	Yes
Observations	1,112,994	23,276	587,882	328,802	173,034	643,502	443,632
R-squared	0.362	0.555	0.506	0.518	0.596	0.301	0.420

Notes: Results in this table are estimated using a triple difference specification at the program level. Variable $STEM$ categorizes the STEM status of programs (6-digit CIP) using the 2012 STEM program list published by the Department of Homeland Security. Variable *Post* is 1 when year is later than 2012, 0 otherwise. Variable *Colonial* categorizes colonial history of each country, it equals 1 if a country was colonized by Great Britain, and 0 otherwise. The country-level historical colonial link data come from CEPII's GeoDist dataset. Administrative international enrollment data are from the U.S. Immigration and Customs Enforcement (ICE), collapsed to program level. Categorization of public 4-year universities and private not-for-profit universities is based on university sector categorization from IPEDS. All specifications include school by year and school by major fixed effects. Columns (1), (6), and (7) additionally include degree by year fixed effects. Robust standard errors, reported in parentheses, are two-way clustered at school and major level. *** p<0.01, ** p<0.05, * p<0.1

Table III: First-Stage IV strength

	(1) Total	(2) Associate's	(3) Bachelor's	(4) Master's	(5) Doctorate	(6) Public 4-yr	(7) Private NFP
IV	1.344***	1.538	-0.0317	1.396***	0.400	1.265***	1.169**
	(0.386)	(2.540)	(0.203)	(0.365)	(0.524)	(0.372)	(0.462)
Kleibergen-Paap F	12.05	0.41	0.02	14.16	0.72	11.88	6.12
Observations	512,121	6,632	265,475	148,463	80,730	303,990	199,620
R-squared	0.511	0.859	0.737	0.771	0.806	0.464	0.545

Notes: Administrative international enrollment data are from the U.S. Immigration and Customs Enforcement (ICE), collapsed to program level. Categorization of public 4-year universities and private not-for-profit universities is based on university sector categorization from IPEDS. All specifications include school by year and school by major fixed effects. Columns (1), (6), and (7) additionally include degree by year fixed effects. Robust standard errors, reported in parentheses, are two-way clustered at school and major level. *** p<0.01, ** p<0.05, * p<0.1

Table IV: Effect of Overall International Enrollment on Domestic Completion

VARIABLES	(1) OLS	(2) Total	(3) Master's	(4) Public 4-yr	(5) Pub-Master's	(6) Selective Pub
Current year						
International	0.821***	0.324*	-0.00630	0.258	0.0119	0.0714
	(0.206)	(0.181)	(0.0521)	(0.283)	(0.0740)	(0.306)
1 year later						
International	0.836***	0.465**	0.00659	0.505*	0.0452	0.308
	(0.208)	(0.213)	(0.0645)	(0.292)	(0.0724)	(0.308)
2 years later						
International	0.831***	0.560***	0.0670	0.758**	0.0915	0.535*
	(0.207)	(0.206)	(0.0556)	(0.305)	(0.0750)	(0.313)
3 years later						
International	0.816***	0.613***	0.0693	0.950***	0.114	0.732**
	(0.206)	(0.206)	(0.0497)	(0.325)	(0.0785)	(0.335)
4 years later						
International	0.810***	0.691***	0.0988*	1.115***	0.171*	0.916**
	(0.207)	(0.216)	(0.0519)	(0.345)	(0.0879)	(0.361)
First-stage F	-	12.28	14.75	11.56	13.46	12.22
Observations	538,567	512,113	148,455	303,990	97,486	236,466

Notes: Total number of degrees awarded minus the number of degrees awarded to non-resident alien is used as the number of domestic completion at the program level (6-digit CIP). Domestic completion data are from IPEDS. Administrative international enrollment data are from the U.S. Immigration and Customs Enforcement (ICE), collapsed to program level. Categorization of public 4-year universities and private not-for-profit universities is based on university sector categorization from IPEDS. All specifications include degree by year, school by year, and school by major fixed effects. Robust standard errors, reported in parentheses, are two-way clustered at school and major level. *** p<0.01, ** p<0.05, * p<0.1

Table V: Effect of Master's International Enrollment on Domestic Completion

VARIABLES	(1) OLS	(2) Total	(3) Bachelor's	(4) Master's	(5) Public Total	(6) Hi-Selec Pub	(7) Selec Pub
Current year							
Master's intl	0.0496**	0.0547	0.148	-0.00630	0.0298	0.175	-0.0151
	(0.0199)	(0.0608)	(0.119)	(0.0521)	(0.0891)	(0.191)	(0.0864)
1 year later							
Master's intl	0.0643***	0.107	0.288*	0.00659	0.111	0.329*	0.0469
	(0.0214)	(0.0716)	(0.153)	(0.0645)	(0.0930)	(0.192)	(0.0928)
2 years later							
Master's intl	0.0518***	0.169**	0.419**	0.0670	0.203**	0.433**	0.142
	(0.0144)	(0.0745)	(0.193)	(0.0556)	(0.102)	(0.200)	(0.103)
3 years later							
Master's intl	0.0395**	0.195**	0.515**	0.0693	0.261**	0.544**	0.185
	(0.0161)	(0.0804)	(0.239)	(0.0497)	(0.118)	(0.226)	(0.120)
4 years later							
Master's intl	0.0417**	0.243***	0.633**	0.0988*	0.332**	0.621**	0.256*
	(0.0199)	(0.0913)	(0.275)	(0.0519)	(0.133)	(0.254)	(0.134)
First-stage F	-	14.57	20.19	14.75	12.11	15.56	10.46
Observations	287,530	278,743	70,069	148,455	187,806	37,711	145,415

Notes: Total number of degrees awarded minus the number of degrees awarded to non-resident alien is used as the number of domestic completion at the program level (6-digit CIP). Domestic completion data are from IPEDS. Administrative international enrollment data are from the U.S. Immigration and Customs Enforcement (ICE), collapsed to program level. Categorization of public 4-year universities and private not-for-profit universities is based on university sector categorization from IPEDS. All specifications include degree by year, school by year, and school by major fixed effects. Robust standard errors, reported in parentheses, are two-way clustered at school and major level. *** p<0.01, ** p<0.05, * p<0.1

Table VI: Effect of Master's International Enrollment on Bachelor's Domestic Completion by Gender and Race/Ethnicity

VARIABLES	(1) Total	(2) Male	(3) Female	(4) White	(5) Black	(6) Hispanic	(7) Asian
Current year							
Master's intl	0.148	0.116	0.0323	0.180**	-0.00287	-0.0644**	0.0204
	(0.119)	(0.0818)	(0.0503)	(0.0879)	(0.00945)	(0.0268)	(0.0253)
1 year later							
Master's intl	0.288*	0.218**	0.0703	0.267**	0.00705	-0.0641**	0.0502*
	(0.153)	(0.108)	(0.0592)	(0.113)	(0.0106)	(0.0310)	(0.0295)
2 years later							
Master's intl	0.419**	0.320**	0.0988	0.335**	0.0116	-0.0528	0.0820**
	(0.193)	(0.139)	(0.0668)	(0.135)	(0.0111)	(0.0338)	(0.0389)
3 years later							
Master's intl	0.515**	0.410**	0.105	0.378**	0.0224	-0.0432	0.111**
	(0.239)	(0.173)	(0.0789)	(0.152)	(0.0142)	(0.0396)	(0.0555)
4 years later							
Master's intl	0.633**	0.488**	0.145	0.420***	0.0350**	-0.0337	0.151**
	(0.275)	(0.195)	(0.0924)	(0.162)	(0.0171)	(0.0466)	(0.0688)
First-stage F	20.19	20.19	20.19	20.19	20.19	20.19	20.19
Observations	70,069	70,069	70,069	70,069	70,069	70,069	70,069

Notes: Total number of degrees awarded minus the number of degrees awarded to non-resident alien is used as the number of domestic completion at the program level (6-digit CIP). Domestic completion data are from IPEDS. Administrative international enrollment data are from the U.S. Immigration and Customs Enforcement (ICE), collapsed to program level. All specifications include degree by year, school by year and school by major fixed effects. Robust standard errors, reported in parentheses, are two-way clustered at school and major level. *** p<0.01, ** p<0.05, * p<0.1

Table VII: Effect of New International Enrollment on Financial Aid

VARIABLES	# Institutional Grant Awards			Average Instutional Grant Awards			Total Student Aid Amount			Tuition&Fees Allowances		
	Total	Public 4-yr	Private NFP	Total	Public 4-yr	Private NFP	Total	Public 4-yr	Private NFP	Total	Public 4-yr	Private NFP
Current year												
International	0.00166***	0.00246***	0.000466*	0.0114***	0.00588***	0.0230***	431.0***	327.1***	506.2***	350.7***	215.7***	467.1***
	(0.000449)	(0.000492)	(0.000256)	(0.00329)	(0.00154)	(0.00540)	(32.82)	(46.08)	(61.59)	(27.75)	(35.30)	(52.03)
1 year later												
International	0.00160***	0.00238***	0.000403	0.0129***	0.00579***	0.0266***	451.9***	328.2***	556.4***	366.9***	217.4***	508.2***
	(0.000433)	(0.000511)	(0.000278)	(0.00353)	(0.00146)	(0.00591)	(36.22)	(42.74)	(72.64)	(31.97)	(33.59)	(59.13)
2 years later												
International	0.00151***	0.00197***	0.000452	0.0142***	0.00639***	0.0304***	483.2***	325.8***	626.2***	395.4***	219.6***	574.4***
	(0.000406)	(0.000525)	(0.000296)	(0.00404)	(0.00142)	(0.00584)	(39.26)	(44.94)	(84.90)	(40.97)	(35.76)	(70.15)
Observations	21,037	6,525	12,367	6,471	6,949	12,188	22,352	6,764	13,320	21,529	6,740	13,031
First-stage F	59.72	75.01	20.82	74.97	68.63	21.14	58.84	74.52	20.51	65.86	74.50	20.53

Notes: Financial aid data are from IPEDS. Administrative international enrollment data are from the U.S. Immigration and Customs Enforcement (ICE), collapsed to program level. Categorization of public 4-year universities and private not-for-profit universities is based on university sector categorization from IPEDS. All specifications include school and year fixed effects. Robust standard errors, reported in parentheses, are clustered at school level. *** p<0.01, ** p<0.05, * p<0.1

Table VIII: Effect of U.K. Policy Change on Program-Level Tuition Revenue from International Students (in 2018 Dollars)

VARIABLES	(1) Total	(2) Associate's	(3) Bachelor's	(4) Master's	(5) Doctorate	(6) Public 4-yr	(7) Private NFP
Panel A. Total intl tuition revenue							
STEM*Post	43,060	-38,774	10,415	132,311**	843.1	56,648**	22,432
	(26,704)	(40,875)	(26,268)	(63,790)	(3,854)	(25,655)	(33,766)
Observations	538,726	8,391	279,794	155,409	83,411	316,033	212,168
R-squared	0.513	0.884	0.727	0.803	0.837	0.429	0.548
Panel B. Tuition revenue from non-colonial intl students							
STEM*Post	6,164	-35,511	1,830	18,026	3,076	11,720	-767.9
	(18,776)	(37,470)	(22,666)	(37,317)	(3,236)	(16,737)	(26,462)
Observations	538,726	8,391	279,794	155,409	83,411	316,033	212,168
R-squared	0.509	0.870	0.698	0.795	0.732	0.421	0.549
Panel C. Tuition revenue from colonial intl students							
STEM*Post	36,896***	-3,262	8,584	114,284***	-2,233*	44,928***	23,200*
	(11,938)	(3,969)	(5,918)	(37,273)	(1,195)	(13,480)	(12,308)
Observations	538,726	8,391	279,794	155,409	83,411	316,033	212,168
R-squared	0.424	0.885	0.706	0.710	0.877	0.353	0.461

Notes: Results in this table are estimated using a difference-in-differences specification at the program level. Variable *STEM* categorizes the STEM status of programs (6-digit CIP) using the 2012 STEM program list published by the Department of Homeland Security. Variable *Post* is 1 when year is later than 2012, 0 otherwise. Variable. Non-colonial international students are from countries that have not been colonized by the Great Britain; Colonial international students are from countries that have been colonized by the Great Britain. The country-level historical colonial link data come from CEPII's GeoDist dataset. Administrative international tuition data are from the U.S. Immigration and Customs Enforcement (ICE), collapsed to program level. Categorization of public 4-year universities and private not-for-profit universities is based on university sector categorization from IPEDS. All specifications include school by year and school by major fixed effects. Columns (1), (6), and (7) additionally include degree by year fixed effects. Robust standard errors, reported in parentheses, are two-way clustered at school and major level. *** p<0.01, ** p<0.05, * p<0.1

X Figures

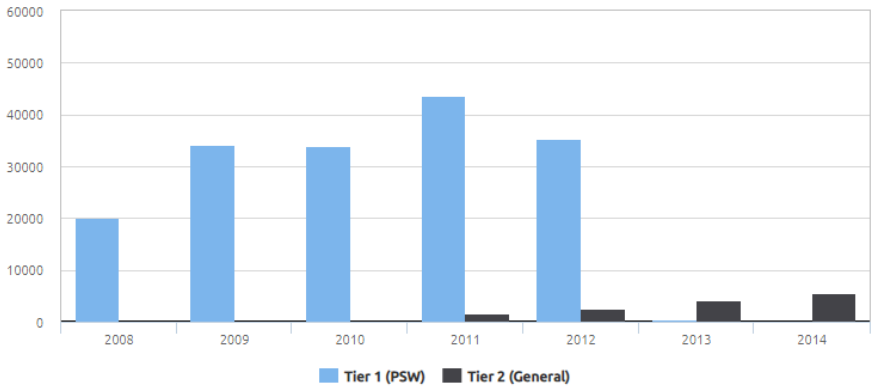


Figure I: Number of Tier 1 (Post-Study Work) Visas and Number of Tier 2 (General) Visas Granted to Previous Students

Source: Migration Watch UK

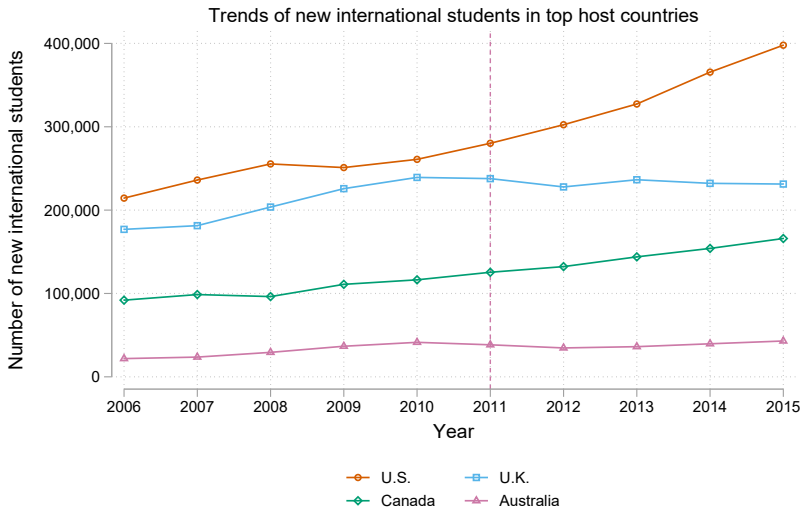


Figure II: New International Student Enrollment in Top Host Countries

Notes: This figure plots the raw trends of new international student enrollment in the U.S., the U.K., Canada, and Australia over time. The U.S. international student data are from the U.S. Immigration and Customs Enforcement (ICE). The U.K. international student data are from the U.K. Higher Education Statistics Agency (HESA). Canadian international student data are from Immigration, Refugees and Citizenship Canada (IRCC). Australian international student data come from the Australian Department of Education, Skills and Employment. The vertical line signals the year that the U.K. immigration policy change was announced.

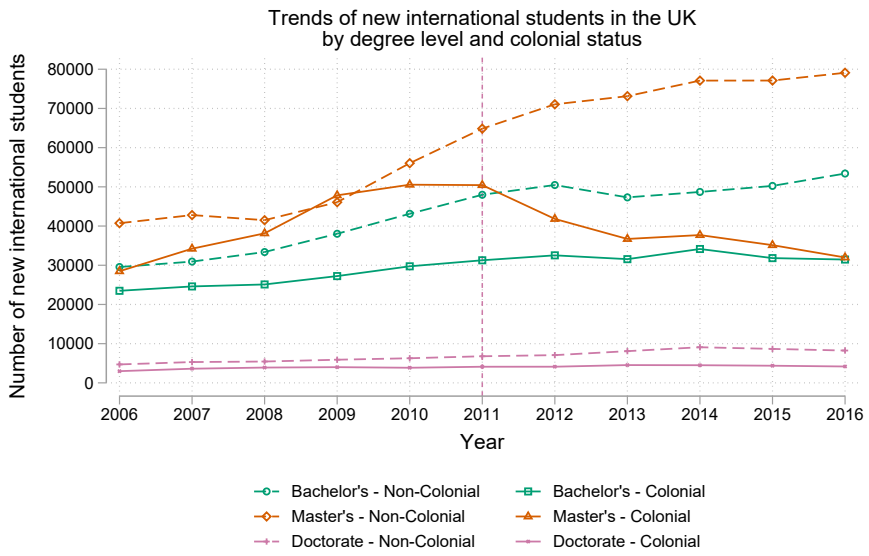


Figure III: New International Student Enrollment in the U.K.
by Degree Level and Home Country's Colonial Status

Notes: This figure plots the raw trends of new non-EU international student enrollment in the U.K. over time by degree level and students' home countries' colonial status. Administrative international student data are from Higher Education Statistics Agency (HESA). Country-level historical colonial link data come from CEPII's GeoDist dataset. The vertical line signals the year that the U.K. immigration policy change was announced.

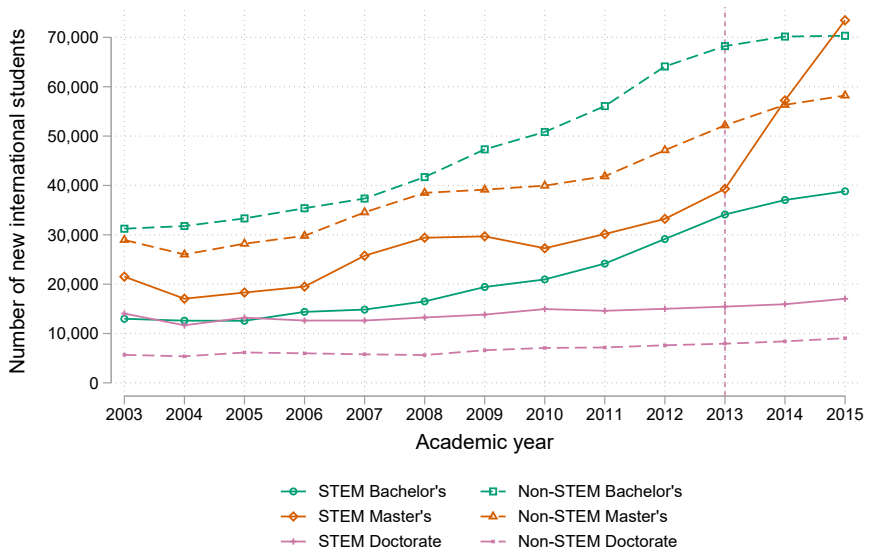
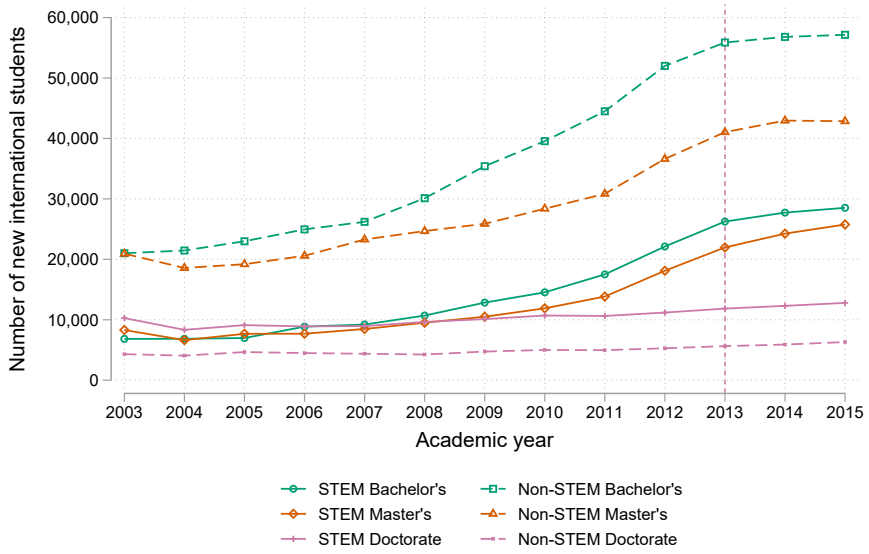


Figure IV: Trends of New International Students in the U.S. by Degree Level and STEM Status

Notes: This figure plots the raw trends of new international enrollment in the analysis sample over time by degree level and program's STEM status. Administrative international student data are from the U.S. Immigration and Customs Enforcement (ICE). STEM status of programs (6-digit CIP) is categorized using the 2012 STEM program list published by the Department of Homeland Security. The vertical line signals the earliest year that the U.K. immigration policy change could affect international student enrollment in the U.S.

Panel A. Non-Colonial International Students



Panel B. Colonial International Students

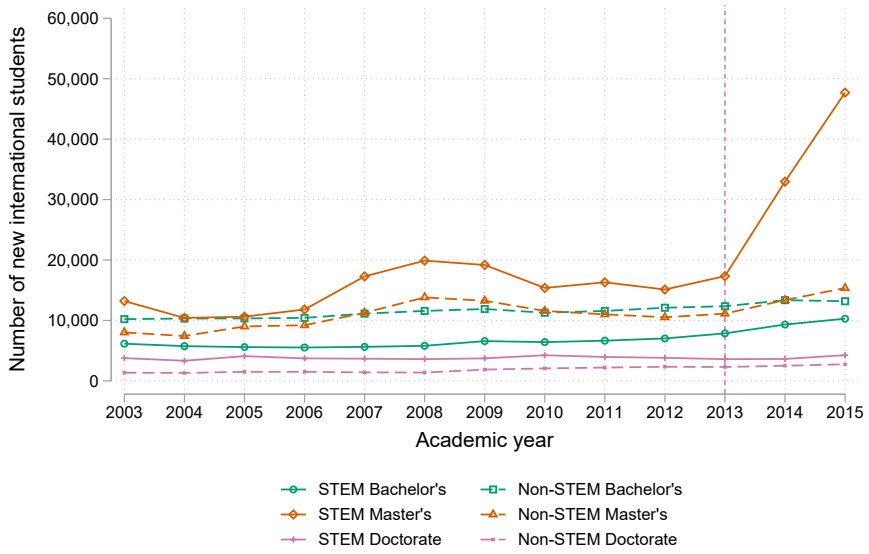


Figure V: Trends of New International Students in the U.S.
by Degree Level, STEM Status, and Home Countries' Colonial Status

Notes: These figures plot the raw trends of new international enrollment in the analysis sample over time for students from non-former British colonial countries (panel A) and those from former British colonial countries (panel B), and by degree level and program's STEM status. Administrative international student data are from the U.S. Immigration and Customs Enforcement (ICE). STEM status of programs (6-digit CIP) is categorized using the 2012 STEM program list published by the Department of Homeland Security. Country-level historical colonial link data come from CEPII's GeoDist dataset. The vertical line signals the earliest year that the U.K. immigration policy change could affect international student enrollment in the U.S.

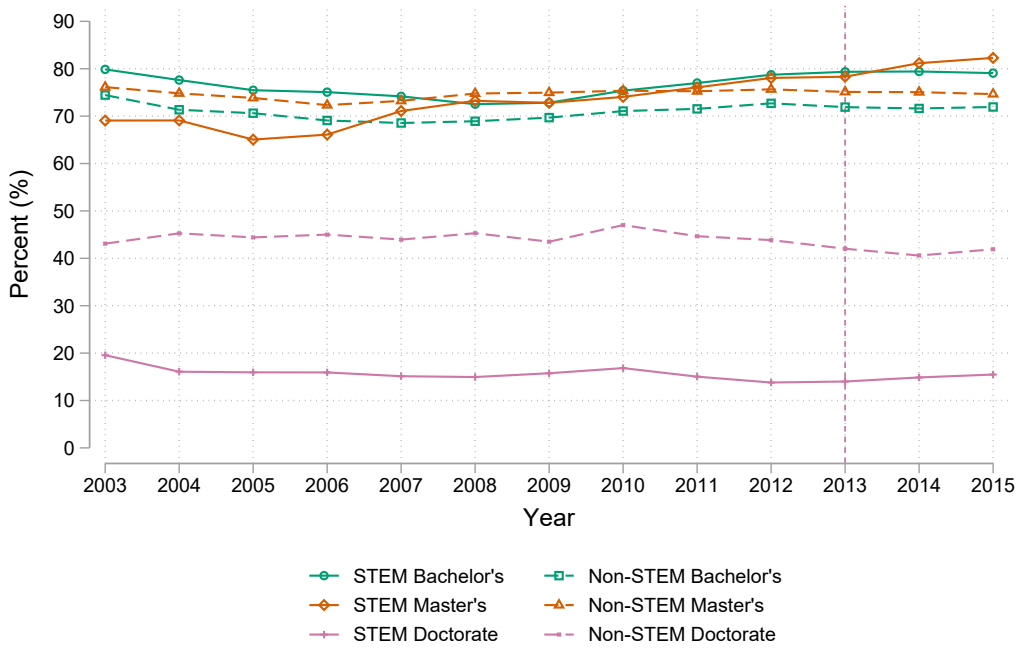
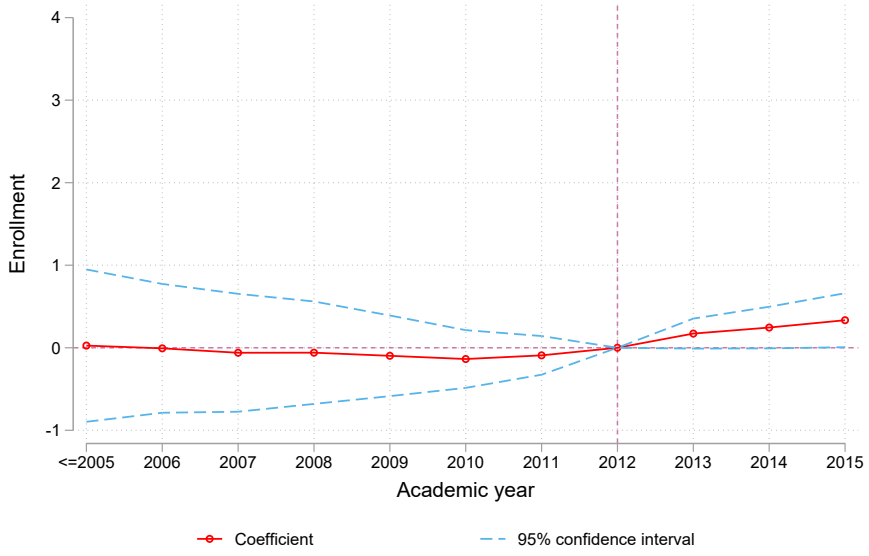


Figure VI: Trends of New International Student Funding
by Degree Level and STEM Status

Notes: This figure plots the raw trends of the percent of new international students receiving no institutional aid from the enrolled school by degree level, program's STEM status, and year. The administrative international student data are from the U.S. Immigration and Customs Enforcement (ICE). The vertical line signals the earliest year that the U.K. immigration policy change could affect international student enrollment in the U.S.

Panel A. Non-Colonial International Students



Panel B. Colonial International Students

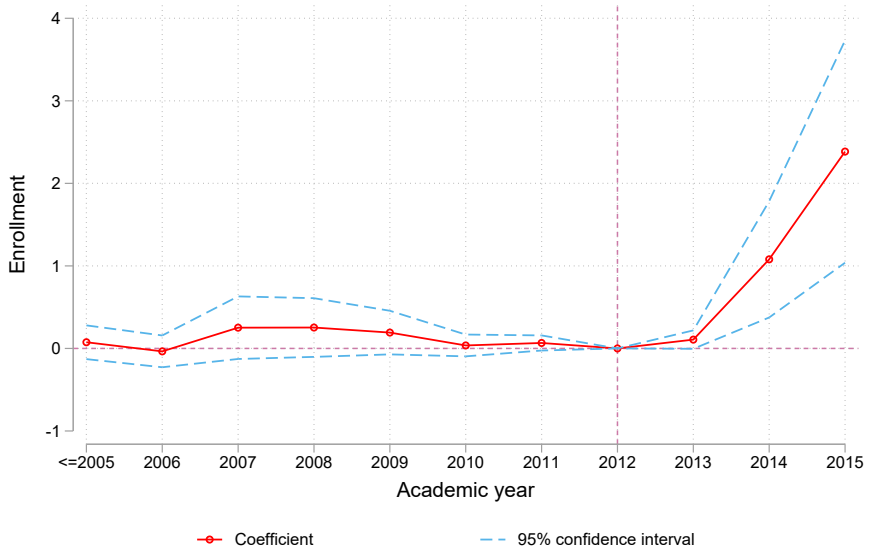


Figure VII: Event studies of the Effect of U.K. Immigration Policy Change on New U.S. International Enrollment, by Home Countries' Colonial Status

Notes: These figures plot coefficients and 95% confidence intervals from event-study regressions that estimate the effect of the U.K. immigration policy change on new international enrollment in U.S. university programs. The outcome in panel A and B is the number of new international students from non-former British colonial countries and from former British colonial countries, respectively, at the program level. Year 2012 is excluded from the analysis so that all regression coefficients are relative to 2012, the year immediately preceding the U.K. immigration policy change. The regressions include degree by year, school by year, and school by major fixed effects. Standard errors are two-way clustered at the school and major level.

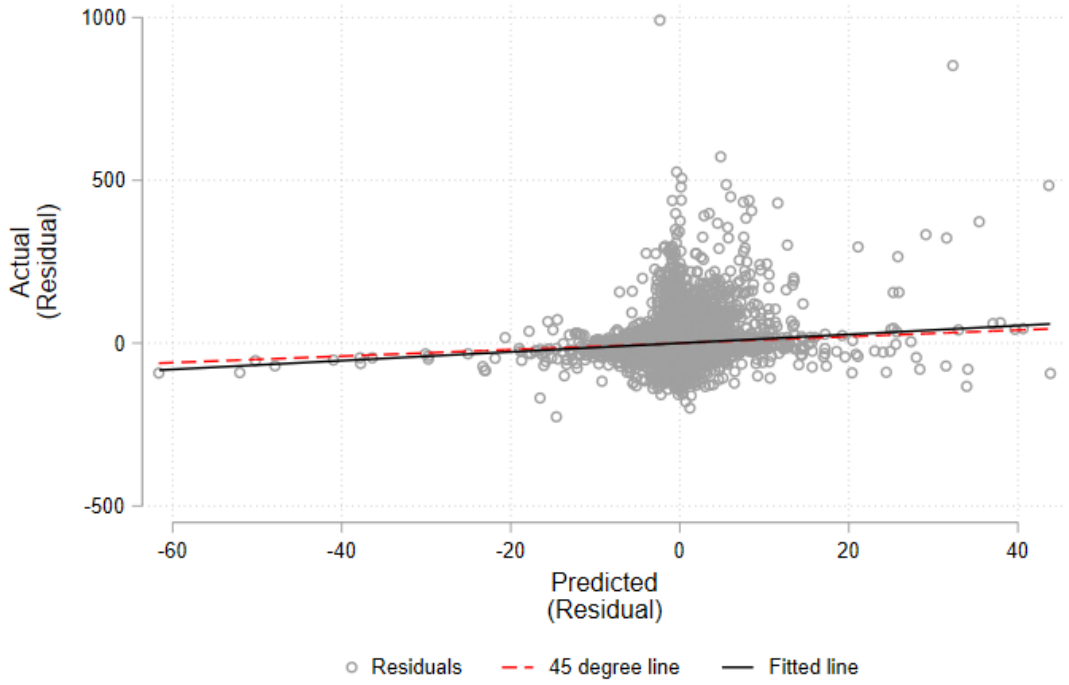


Figure VIII: Visual First-Stage Estimates

Notes: This figure plots the actual number of new international students against the predicted number of new international students for each program.

Appendix

A Post-graduation visa policies in Canada and Australia

Canada introduced its Post Graduation Work Permit program in 2005, under which international students who obtain a job offer in their field of study could stay and work for one year (two years if the job was outside Toronto, Vancouver, and Montreal) after graduation. The program was expanded significantly starting April 2008. Under the new policy, international students are able to obtain an open work permit with no restrictions on the type of employment and no requirement for a job offer. The length of the work permit depends on student's study program length – if a program is between eight months and two years long, the work permit is of the same length as the program length; if a program's length is two years or longer, the work permit is three years in length.

Australia's Post-Study Work visa program was implemented in 2013. Before the introduction of the program, international students with at least a Bachelor's degree were able to stay and work in the country for 18 months using the Temporary Skilled Graduate Visa program. Under the new policy starting 2013, students graduated with a Bachelor's or Master's by coursework degree can stay and work for two years, while those with a Master's by research and PhD degree are eligible to stay and work for three and four years, respectively.

Table A1 includes two examples of different lengths of post-graduation work visa under each country's new policy. If an international student intends to obtain a one-academic-year (10-month) coursework-based master's degree in a non-STEM field, he/she would be eligible for relatively similar amount of post-graduation work permit under the rules in both the U.S. and Canada (about a year), while he/she would receive the most generous amount from Australia (two years) and the least generous amount from the U.K. (two months). On the other hand, if an international student plans to study in a master's program of same length in a STEM field, the lengths of post-graduation visa stay the same under the new policy in the U.K., Canada, and Australia; however, the student is now eligible to stay and work in the U.S. for up to 29 months without additional employer sponsorship. Therefore, if the ability to stay and work in the country of study plays a role in the decision-making process of an international student who plans to study in a STEM field, it is clear that the U.S. would have a competitive advantage over the other top destination countries in terms of post-graduation visa policy.

Table A1: Post-Graduation Visa Policies in Top Host Countries

	U.S.	U.K.	Canada	Australia
Before policy change	12 months	2 years	1 year (2 years if outside 3 largest cities), job offer required	18 months
Policy change year	2008	2012	2008	2013
After policy change	Non-STEM: 12 months; STEM: up to 29 months	2-4 months, depending on program length	8 months-3 years, depending on program length	2-4 years, depending on degree level
If graduated from a 10-month non-STEM master's program after 2012	12 months	2 months	10 months	2 years
If graduated from a 10-month STEM master's program after 2012	29 months	2 months	10 months	2 years

B Alternative IV Strategy

I explore an alternative IV strategy to solidify the main findings. Specifically, instead of constructing an instrument for the number of new international students at the program level after the triple difference estimation, I modify the triple difference specification into a triple difference with treatment intensity. I estimate the effect of the U.K. immigration policy change on new international enrollment in the U.S. at the program level with the following form:

$$International_{mdst} = \beta_0 + \beta_1 STEM_m \times Post_t \times Ratio_{ms} + \beta_2 STEM_m \times Post_t + \beta_3 Post_t \times Ratio_{ms} + \alpha_{dt} + \delta_{st} + \gamma_{sm} + \epsilon_{mdst}, \quad (9)$$

where $International_{mdst}$ is the number of new international students in major m, at degree level d, in school s, in year t. $STEM_m$ and $Post_t$ are all dummy variables that equal to 1 if major m is categorized as STEM, year t is after 2012, the year the U.K. policy change went into effect. $Ratio_{ms}$ is the first term in equation (4), which is the share of colonial students out of all international students in major m in school s in baseline years over the average share of colonial students across all programs in baseline years. The variables α_{dt}, δ_{st}, and γ_{sm} are degree by year, school by year, and school by major fixed effects, respectively. Standard errors are two-way clustered at the school and major level. The results are shown in Table B1. Consistent with what the triple difference specification in the main text, the effect is positive and significant for total, master's degree level, and public 4-year institutions, as well as private not-for-profit schools.

I then use the term $STEM_m \times Post_t \times Ratio_{ms}$ to directly instrument for the number of new international students at the program level in a two-stage least square specification to estimate the causal effect of international enrollment on domestic completion. Formally,

$$Domestic_{mdst} = \beta_0 + \beta_1 \widehat{International}_{mdst} + \alpha_{dt} + \delta_{st} + \gamma_{sm} + \epsilon_{mdst}, \quad (10)$$

$$International_{mdst} = \beta_1 STEM_m \times Post_t \times Ratio_{ms} + \alpha_{dt} + \delta_{st} + \gamma_{sm} + \epsilon_{mdst}, \quad (11)$$

where $Domestic_{mdst}$ is the number of domestic student completions from major m, in degree level d, from school s, in year t. $International_{mdst}$ is the number of new international students in major m, in degree level d, from school s, in year t that is instrumented using the IV. α_{dt}, δ_{st}, and γ_{sm} are degree-by-year, school-by-year, and school-by-major fixed effects, respectively. Standard errors are two-way clustered at the school and major level. The

first-stage equation (11) has similar form as equation (9), though the $STEM_m \times Post_t$ and $Post_t \times Ratio_{ms}$ terms have to be dropped due to collinearity. The excluded instrument for $International_{mdst}$ is the three-way interaction term $STEM_m \times Post_t \times Ratio_{ms}$. The first-stage results are shown in Table B2. Again, consistent with the specification in the main text, the instrument is relatively strong for overall, master's, and public 4-year institutions, though the F-statistics are smaller compared to the main specification.

The 2SLS results for overall effects of international enrollment and effects of master's international enrollment are shown in Table B3 and Table B4, respectively. Results for both the overall international enrollment and master's international enrollment are consistent with the results in the main specification qualitatively. However, the magnitude of the effect size is larger under the alternative IV specification. This shows that the main findings in the paper could be the conservative estimates of the resource effects of international students on domestic completion.

Table B1: Effect of U.K. Immigration Policy Change on New International Enrollment in the U.S. - Alternative Specification

VARIABLES	(1) Total	(2) Associate's	(3) Bachelor's	(4) Master's	(5) Doctorate	(6) Public 4-yr	(7) Private NFP
STEM*Post*Ratio	1.416***	0.919	0.360	4.220***	0.0717	1.747***	1.030**
	(0.400)	(1.102)	(0.236)	(1.210)	(0.101)	(0.450)	(0.439)
STEM*Post	-0.300	-2.700	0.0503	-1.524	0.0460	-0.388	-0.261
	(0.463)	(3.335)	(0.657)	(1.014)	(0.141)	(0.506)	(0.568)
Post*Ratio	-0.271**	0.923	-0.194	-0.597**	0.0565	-0.188	-0.437***
	(0.120)	(0.789)	(0.120)	(0.294)	(0.0542)	(0.133)	(0.150)
School by year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School by program FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Degree by year FE	Yes	No	No	No	No	Yes	Yes
Observations	512,121	6,632	265,475	148,463	80,730	303,990	199,620
R-squared	0.504	0.858	0.737	0.759	0.806	0.460	0.540

Notes: Results in this table are estimated using a triple difference specification at the program level. Variable *STEM* categorizes the STEM status of programs (6-digit CIP) using the 2012 STEM program list published by the Department of Homeland Security. Variable *Post* is 1 when year is later than 2012, 0 otherwise. The country-level historical colonial link data come from CEPII's GeoDist dataset. Administrative international enrollment data are from the U.S. Immigration and Customs Enforcement (ICE), collapsed to program level. Categorization of public 4-year universities and private not-for-profit universities is based on university sector categorization from IPEDS. All specifications include degree by year, school by year, and school by major fixed effects. Robust standard errors, reported in parentheses, are two-way clustered at school and major level. *** p<0.01, ** p<0.05, * p<0.1

Table B2: IV First-Stage Overall - Alternative IV

	(1) Total	(2) Associate's	(3) Bachelor's	(4) Master's	(5) Doctorate	(6) Public 4-yr	(7) Private NFP
IV	1.127***	0.0690	0.291	3.125***	0.125	1.446***	0.700
	(0.414)	(0.263)	(0.282)	(1.041)	(0.102)	(0.438)	(0.431)
Kleibergen-Paap F	7.430	0.0690	1.064	9.047	1.509	10.91	2.691
Observations	512,121	6,632	265,475	148,463	80,730	303,990	199,620
R-squared	0.504	0.858	0.737	0.759	0.806	0.460	0.540

Notes: Administrative international enrollment data are from the U.S. Immigration and Customs Enforcement (ICE), collapsed to program level. Categorization of public 4-year universities and private not-for-profit universities is based on university sector categorization from IPEDS. All specifications include degree by year, school by year, and school by major fixed effects. Robust standard errors, reported in parentheses, are two-way clustered at school and major level. *** p<0.01, ** p<0.05, * p<0.1

Table B3: Effect of Overall International Enrollment on Domestic Completion Alternative IV

VARIABLES	(1) Total	(2) Master's	(3) Public 4-yr	(4) Selective Pub
Current year				
International	0.293	-0.125	0.170	-0.0968
	(0.810)	(0.152)	(0.747)	(0.807)
1 year later				
International	1.027	0.0237	0.798	0.486
	(0.879)	(0.155)	(0.755)	(0.811)
2 years later				
International	1.596*	0.144	1.328*	0.981
	(0.900)	(0.160)	(0.755)	(0.800)
3 years later				
International	1.973**	0.168	1.720**	1.363*
	(0.889)	(0.170)	(0.751)	(0.793)
4 years later				
International	2.252**	0.219	2.007***	1.687**
	(0.873)	(0.184)	(0.753)	(0.800)
First-stage F	7.430	9.047	10.91	10.65
Observations	512,113	148,455	303,990	236,466

Notes: Total number of degrees awarded minus the number of degrees awarded to non-resident alien is used as the number of domestic completion at the program level (6-digit CIP). Domestic completion data are from IPEDS. Administrative international enrollment data are from the U.S. Immigration and Customs Enforcement (ICE), collapsed to program level. Categorization of public 4-year universities and private not-for-profit universities is based on university sector categorization from IPEDS. All specifications include degree by year, school by year, and school by major fixed effects. Robust standard errors, reported in parentheses, are two-way clustered at school and major level. *** p<0.01, ** p<0.05, * p<0.1

Table B4: Effect of Master's International Enrollment on Domestic Completion Alternative IV

VARIABLES	(1) Total	(2) Bachelor's	(3) Master's	(4) Public Total	(5) Hi-Selec Pub	(6) Selective Pub
Current year						
Master's intl	0.241	0.859	-0.125	0.154	0.563	0.0176
	(0.240)	(0.606)	(0.152)	(0.234)	(0.338)	(0.244)
1 year later						
Master's intl	0.463*	1.322*	0.0237	0.391	0.808**	0.258
	(0.272)	(0.687)	(0.155)	(0.264)	(0.384)	(0.268)
2 years later						
Master's intl	0.640**	1.697**	0.144	0.610**	0.997**	0.498*
	(0.293)	(0.753)	(0.160)	(0.289)	(0.424)	(0.292)
3 years later						
Master's intl	0.735**	1.941**	0.168	0.758**	1.176**	0.640**
	(0.312)	(0.823)	(0.170)	(0.319)	(0.470)	(0.323)
4 years later						
Master's intl	0.859	2.220**	0.219	0.883**	1.280**	0.775**
	(0.606)	(0.902)	(0.184)	(0.353)	(0.507)	(0.362)
First-stage F	8.367	8.273	9.047	9.300	6.117	8.900
Observations	278,743	70,069	148,455	187,806	37,711	145,415

Notes: Total number of degrees awarded minus the number of degrees awarded to non-resident alien is used as the number of domestic completion at the program level (6-digit CIP). Domestic completion data are from IPEDS. Administrative international enrollment data are from the U.S. Immigration and Customs Enforcement (ICE), collapsed to program level. Categorization of public 4-year universities and private not-for-profit universities is based on university sector categorization from IPEDS. All specifications include degree by year, school by year, and school by major fixed effects. Robust standard errors, reported in parentheses, are two-way clustered at school and major level. *** p<0.01, ** p<0.05, * p<0.1

C Additional Tables

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Table C1: List of International Student Home Countries that are Former British Colonies

Country	**Continent**
BOTSWANA	Africa
EGYPT	Africa
ERITREA	Africa
ESWATINI	Africa
GAMBIA	Africa
GHANA	Africa
KENYA	Africa
LESOTHO	Africa
MALAWI	Africa
MAURITIUS	Africa
NIGERIA	Africa
SAINT HELENA	Africa
SEYCHELLES	Africa
SIERRA LEONE	Africa
SOMALIA	Africa
SOUTH AFRICA	Africa
SUDAN	Africa
UGANDA	Africa
UNITED REPUBLIC OF TANZANIA	Africa
ZAMBIA	Africa
ZIMBABWE	Africa
ANGUILLA	America
ANTIGUA AND BARBUDA	America
BAHAMAS	America
BARBADOS	America
BELIZE	America
BERMUDA	America
BRITISH VIRGIN ISLANDS	America
CANADA	America
CAYMAN ISLANDS	America
DOMINICA	America
FALKLAND ISLANDS (MALVINAS)	America
GRENADA	America
GUYANA	America
JAMAICA	America
MONTSERRAT	America
SAINT KITTS AND NEVIS	America
SAINT LUCIA	America
SAINT VINCENT AND THE GRENADINES	America
TRINIDAD AND TOBAGO	America
TURKS AND CAICOS ISLANDS	America

List of International Student Home Countries that are Former British Colonies (Cont.)

Country	**Continent**
BAHRAIN	Asia
BANGLADESH	Asia
BRUNEI DARUSSALAM	Asia
CHINA, HONG KONG SPECIAL ADMINISTRATIVE REGION	Asia
INDIA	Asia
ISRAEL	Asia
JORDAN	Asia
KUWAIT	Asia
MALAYSIA	Asia
MALDIVES	Asia
MYANMAR	Asia
PAKISTAN	Asia
QATAR	Asia
SINGAPORE	Asia
SRI LANKA	Asia
UNITED ARAB EMIRATES	Asia
YEMEN	Asia
CYPRUS	Europe
AUSTRALIA	Pacific
CHRISMAS ISLAND	Pacific
COCOS (KEELING) ISLANDS	Pacific
COOK ISLANDS	Pacific
FIJI	Pacific
KIRIBATI	Pacific
NAURU	Pacific
NEW ZEALAND	Pacific
NIUE	Pacific
PALAU	Pacific
PAPUA NEW GUINEA	Pacific
SOLOMON ISLANDS	Pacific
TOKELAU	Pacific
TONGA	Pacific
TUVALU	Pacific
VANUATU	Pacific

Notes: Country-level historical colonial link data come from CEPII's GeoDist dataset.

Table C2: Top 25 STEM Master's Programs with Largest Increase in New International Students After 2012

Rank	Institution name	Sector	Program	Before	After	#Increase
1	University of Central Missouri	Public	Computer Science	27	623	596
2	Northwestern Polytechnic University	Private(N)	Electrical and Electronics Engineering	65	487	422
3	New York Institute of Technology	Private(N)	Computer and Information Sciences	8	323	314
4	The University of Texas at Dallas	Public	Computer and Information Sciences	86	340	254
5	Northwest Missouri State University	Public	Computer Systems Analysis/Analyst	48	274	226
6	San Jose State University	Public	Computer Software Engineering	109	332	223
7	University at Buffalo	Public	Computer and Information Sciences	13	201	188
8	International Technological University	Private(N)	Computer Software Engineering	107	285	178
9	The University of Texas at Dallas	Public	Information Science/Studies	91	263	172
10	Texas A & M University-Kingsville	Public	Electrical and Electronics Engineering	56	225	169
11	Wright State University	Public	Electrical and Electronics Engineering	52	221	169
12	Stratford University	Private(F)	Information Science/Studies	3	166	163
13	University of Central Missouri	Public	Information Technology	43	201	158
14	Sullivan University	Private(F)	Information Technology	29	186	157
15	Arizona State University	Public	Computer Science	59	216	157
16	The University of Texas at Arlington	Public	Computer and Information Sciences	56	209	153
17	New York Institute of Technology	Private(N)	Electrical and Electronics Engineering	78	222	144
18	University of Illinois at Springfield	Public	Computer Science	68	211	144
19	Northeastern University	Private(N)	Computer and Information Sciences	42	179	137
20	Valparaiso University	Private(N)	Information Technology	6	142	135
21	University of Missouri-Kansas City	Public	Electrical and Electronics Engineering	48	183	134
22	University of Houston-Clear Lake	Public	Computer Software Engineering	10	140	131
23	Carnegie Mellon University	Private(N)	Information Technology	64	194	130
24	Southern New Hampshire University	Private(N)	Computer and Information Sciences	23	153	130
25	Sacred Heart University	Private(N)	Computer and Information Sciences	7	127	121

Notes: This table shows the average number of international students before and after 2012 for the top 25 STEM master's programs in terms of number of increase. Administrative international enrollment data are from the U.S. Immigration and Customs Enforcement (ICE), collapsed to program level. Program's STEM and non-STEM categorization comes from Department of Homeland Security. Categorization of public 4-year universities (Public), private not-for-profit universities (Private (N)), and private for-profit universities (Private (F)) is based on university sector categorization from IPEDS.

Table C3: First-Stage IV strength using Master's Enrollment

VARIABLES	(1) Total	(2) Associate's	(3) Bachelor's	(4) Master's	(5) Doctorate	(6) Public 4-yr	(7) Private NFP
IV_masters	1.646***	-0.574	2.452***	1.396***	1.648**	1.566***	1.709***
	(0.433)	(0.817)	(0.546)	(0.365)	(0.654)	(0.450)	(0.513)
Kleibergen-Paap F	13.99	1.02	19.42	14.16	5.87	12.10	10.09
Observations	278,751	228	70,069	148,463	49,154	187,806	88,036
R-squared	0.791	0.925	0.800	0.771	0.832	0.728	0.830

Notes: Administrative international enrollment data are from the U.S. Immigration and Customs Enforcement (ICE), collapsed to program level. Categorization of public 4-year universities and private not-for-profit universities is based on university sector categorization from IPEDS. All specifications include school by year and school by major fixed effects. Columns (1), (6), and (7) additionally include degree by year fixed effects. Robust standard errors, reported in parentheses, are two-way clustered at school and major level. *** p<0.01, ** p<0.05, * p<0.1

Table C4: Effect of U.K. Immigration Policy Change on New International Enrollment in the U.S. by School Tier

VARIABLES	(1) Ivy Plus	(2) Other Elite	(3) Hi-Selec Pub	(4) Hi-Selec Priv	(5) Selec Pub	(6) Selec Priv	(7) Non-sel Pub	(8) Non-sel Priv
STEM*Post*Colonial	-0.815	0.117	0.272	-0.390	1.232***	0.674**	1.864*	7.191
	(0.844)	(0.599)	(0.684)	(0.840)	(0.390)	(0.337)	(1.108)	(4.559)
STEM*Post	0.436	0.263	0.734	0.681	0.151	0.180	-1.194	-3.739
	(1.097)	(0.688)	(0.659)	(0.664)	(0.287)	(0.231)	(1.207)	(3.487)
STEM*Colonial	0.481	0.949**	0.534	1.342***	1.083***	0.976***	1.580**	5.197***
	(0.639)	(0.442)	(0.473)	(0.463)	(0.338)	(0.353)	(0.757)	(1.947)
Post*Colonial	-1.840***	-2.449***	-2.259***	-2.355***	-1.264***	-0.816***	-1.727	-2.379***
	(0.406)	(0.479)	(0.489)	(0.517)	(0.220)	(0.143)	(1.067)	(0.777)
Colonial	-2.500***	-2.178***	-1.978***	-1.826***	-1.252***	-0.859***	-2.027**	-2.598***
	(0.769)	(0.429)	(0.433)	(0.442)	(0.271)	(0.301)	(0.787)	(0.601)
School by year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School by program FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Degree by year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	34,336	86,540	115,398	53,772	499,688	237,952	13,248	20,428
R-squared	0.456	0.415	0.323	0.416	0.282	0.299	0.467	0.549

Notes: All specifications include school by year, degree by year, and school by major fixed effects. Standard errors are two-way clustered at school and major level. *** p<0.01, ** p<0.05, * p<0.1

Table C5: Effect of New International Enrollment on University Finances
Revenues

	Total Current Revenue			Net Tuition&Fees Revenue			Net Auxiliary Enterprises Revenue		
VARIABLES	Total	Public 4-yr	Private NFP	Total	Public 4-yr	Private NFP	Total	Public 4-yr	Private NFP
Current year									
International	3,047***	2,649***	3,133***	1,046***	954.4***	1,005***	146.6***	110.4***	166.6***
	(315.9)	(440.2)	(422.4)	(82.91)	(108.3)	(102.1)	(20.94)	(37.64)	(22.29)
1 year later									
International	3,335***	2,825***	3,587***	1,066***	964.7***	1,046***	162.6***	147.7***	167.4***
	(382.6)	(474.7)	(571.2)	(81.36)	(107.2)	(103.7)	(23.66)	(41.26)	(24.46)
2 years later									
International	3,511***	2,885***	3,981***	1,116***	962.9***	1,152***	178.9***	169.7***	176.8***
	(452.2)	(531.7)	(736.7)	(85.78)	(115.8)	(104.7)	(25.46)	(43.59)	(23.19)
Observations	22,533	6,788	13,424	22,486	6,753	13,413	20,615	6,737	12,287
R-squared	0.109	0.262	0.063	0.455	0.528	0.526	0.087	0.046	0.186
First-stage F	50.16	74.54	15.65	50.16	74.51	15.65	65.98	74.24	21.06

Notes: University finance data are from IPEDS. Administrative international enrollment data are from the U.S. Immigration and Customs Enforcement (ICE), collapsed to program level. Categorization of public 4-year universities and private not-for-profit universities is based on university sector categorization from IPEDS. All specifications include school and year fixed effects. Robust standard errors, reported in parentheses, are clustered at school level. *** p<0.01, ** p<0.05, * p<0.1

Table C6: Effect of New International Enrollment on University Finances
Expenditures

	Expenditure on Instruction			Expenditure on Research			Expenditure on Student Service			Expenditure on Academic Support		
VARIABLES	Total	Public 4-yr	Private NFP	Total	Public 4-yr	Private NFP	Total	Public 4-yr	Private NFP	Total	Public 4-yr	Private NFP
Current year												
International	1,034***	704.6***	1,302***	460.0***	413.4***	509.0***	137.2***	99.89***	169.5***	233.5***	277.7***	177.2***
	(186.8)	(92.75)	(364.0)	(80.51)	(79.92)	(128.6)	(24.97)	(19.00)	(50.74)	(46.40)	(41.20)	(63.73)
1 year later												
International	1,057***	712.8***	1,367***	484.2***	419.0***	566.0***	144.0***	97.30***	187.5***	256.2***	301.7***	200.3***
	(185.3)	(104.2)	(360.2)	(86.62)	(81.95)	(141.3)	(25.71)	(20.35)	(52.46)	(49.54)	(41.48)	(75.19)
2 years later												
International	1,123***	716.8***	1,519***	524.9***	439.2***	629.7***	156.1***	97.49***	216.4***	274.7***	323.5***	213.1***
	(193.0)	(125.6)	(352.1)	(102.3)	(92.03)	(179.0)	(26.96)	(22.99)	(50.34)	(50.03)	(43.63)	(75.26)
Observations	22,518	6,788	13,410	11,155	6,050	4,830	20,883	6,788	13,276	20,851	6,787	13,246
R-squared	0.374	0.344	0.393	0.254	0.225	0.290	0.214	0.232	0.205	0.177	0.295	0.052
First-stage F	50.16	74.54	15.65	64.49	74.68	20.44	54.11	74.54	14.60	63.89	74.54	19.29

Notes: University finance data are from IPEDS. Administrative international enrollment data are from the U.S. Immigration and Customs Enforcement (ICE), collapsed to program level. Categorization of public 4-year universities and private not-for-profit universities is based on university sector categorization from IPEDS. All specifications include school and year fixed effects. Robust standard errors, reported in parentheses, are clustered at school level. *** p<0.01, ** p<0.05, * p<0.1

Table C7: Effect of U.K. Policy Change on Program-Level Tuition Revenue from International Students by School Tier

VARIABLES	(1) Ivy Plus	(2) Other Elite	(3) Hi-Selec Pub	(4) Hi-Selec Priv	(5) Selec Pub	(6) Selec Priv	(7) Non-sel Pub	(8) Non-sel Priv
Total intl tuition revenue								
STEM*Post	-57,328	16,461	80,845*	36,657	51,435**	32,441	-15,873	80,251
	(124,853)	(58,171)	(44,489)	(38,937)	(23,373)	(24,362)	(35,453)	(129,684)
Observations	17,037	42,646	57,154	26,287	245,338	113,221	6,188	9,297
R-squared	0.510	0.505	0.405	0.600	0.430	0.475	0.767	0.833
Tuition revenue from non-colonial intl students								
STEM*Post	-13,447	6,813	37,557	-5,994	4,075	-3,260	-30,165	36,429
	(103,345)	(48,092)	(36,582)	(30,999)	(13,410)	(13,090)	(29,838)	(101,073)
Observations	17,037	42,646	57,154	26,287	245,338	113,221	6,188	9,297
R-squared	0.496	0.520	0.381	0.595	0.432	0.533	0.774	0.814
Tuition revenue from colonial intl students								
STEM*Post	-43,881	9,648	43,288**	42,652**	47,360***	35,701**	14,291	43,822
	(26,833)	(13,907)	(16,635)	(19,270)	(14,444)	(16,998)	(11,962)	(32,637)
Observations	17,037	42,646	57,154	26,287	245,338	113,221	6,188	9,297
R-squared	0.513	0.410	0.371	0.538	0.341	0.323	0.580	0.754

Notes: All specifications include school by year, degree by year, and school by major fixed effects. Standard errors are two-way clustered at school and major level. *** p<0.01, ** p<0.05, * p<0.1

D Additional Figures

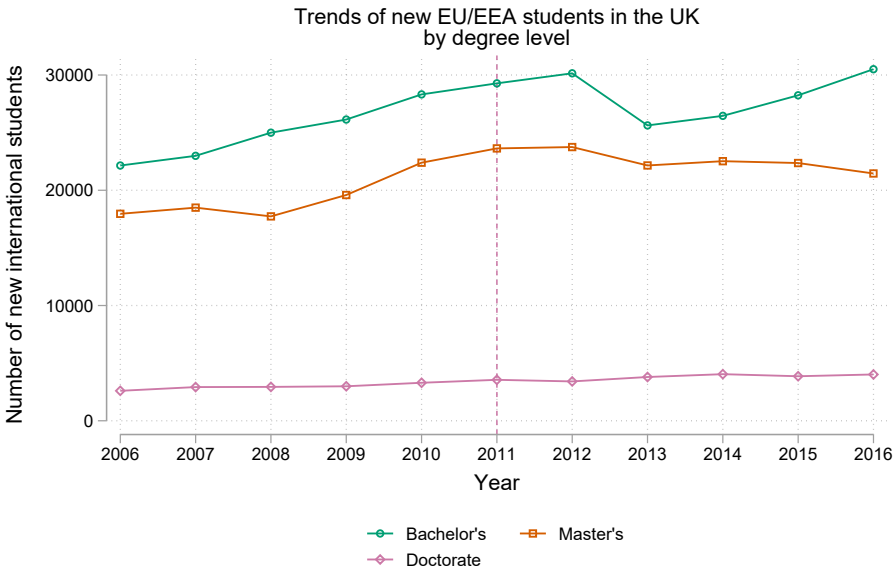


Figure D1: Trends of EU/EEA Students Enrollment in the U.K. by Degree Level

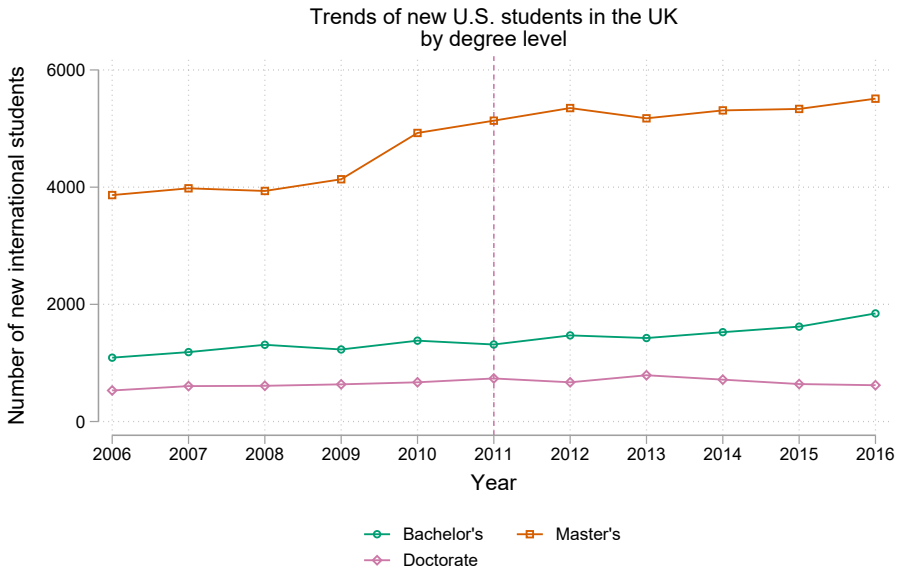


Figure D2: Trends of U.S. Students Enrollment in the U.K. by Degree Level

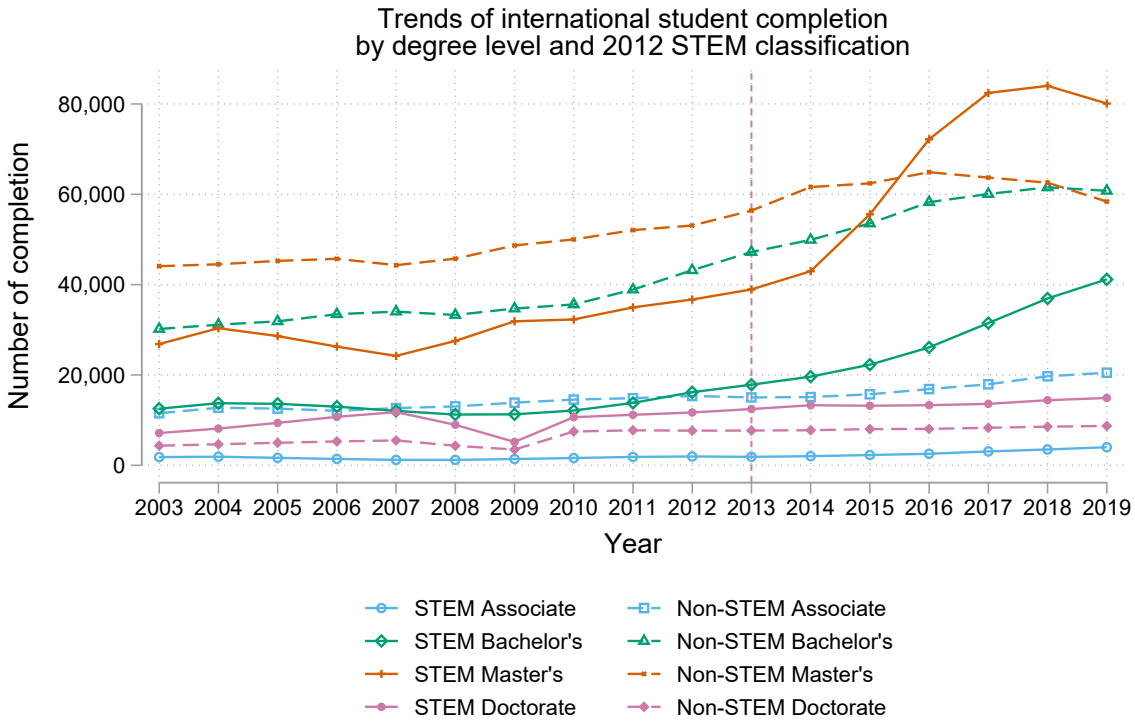
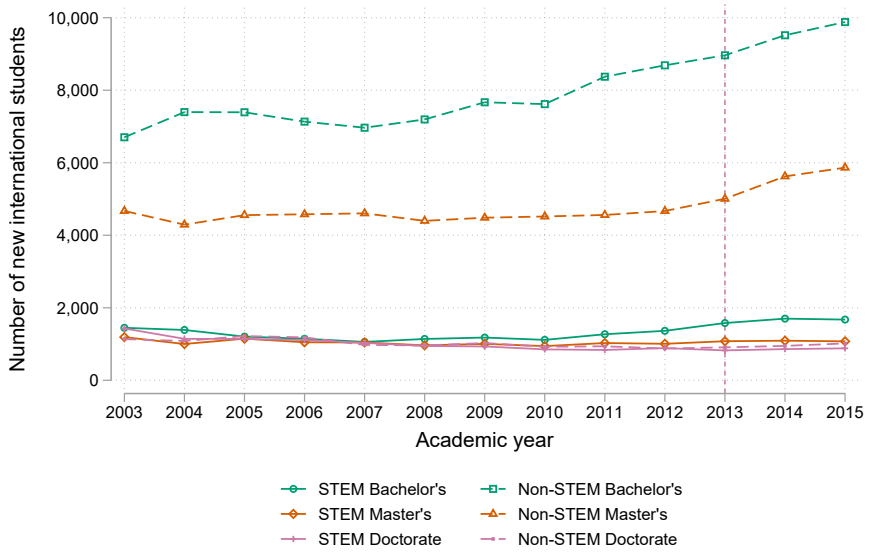


Figure D3: Trends of U.S. International Student Completion, by Degree Level and STEM Status

Panel A. International Students from UK/EU/EEA countries



Panel B. International Students from outside UK/EU/EEA Countries

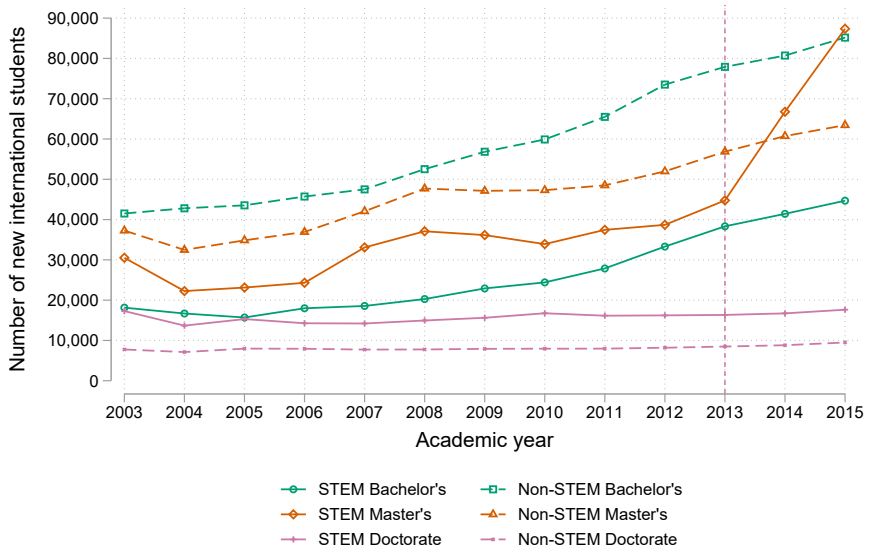


Figure D4: Trends of New International Students in the U.S. by Degree Level, STEM Status, and Home Country

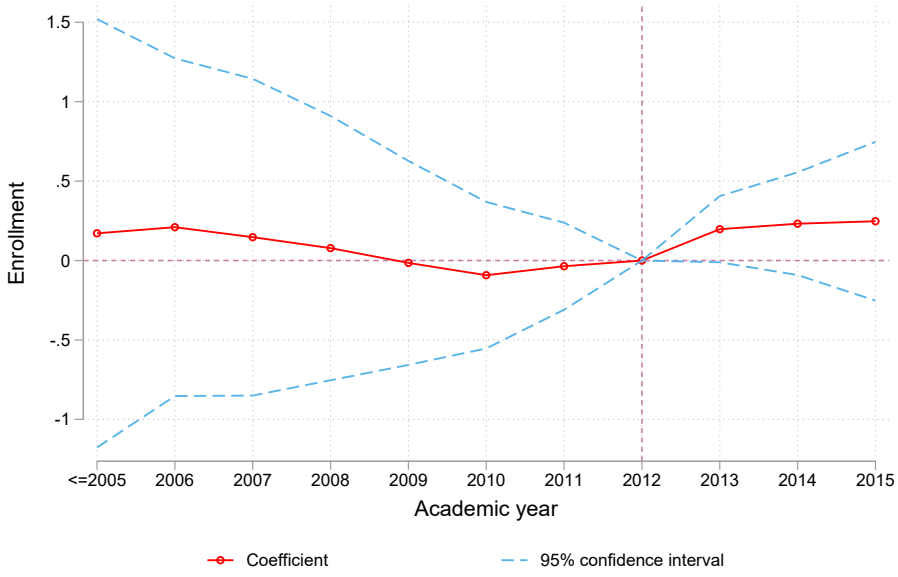


Figure D5: Event study of effect of U.K. policy change on new U.S. international enrollment from non-former British colonial countries - Bachelor's degree

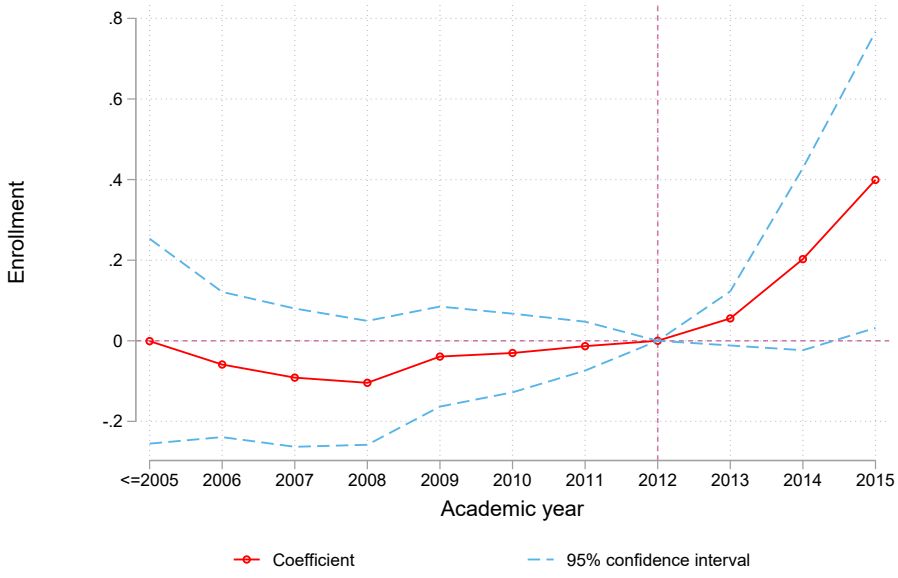


Figure D6: Event study of effect of U.K. policy change on new U.S. international enrollment from former British colonial countries - Bachelor's Degree

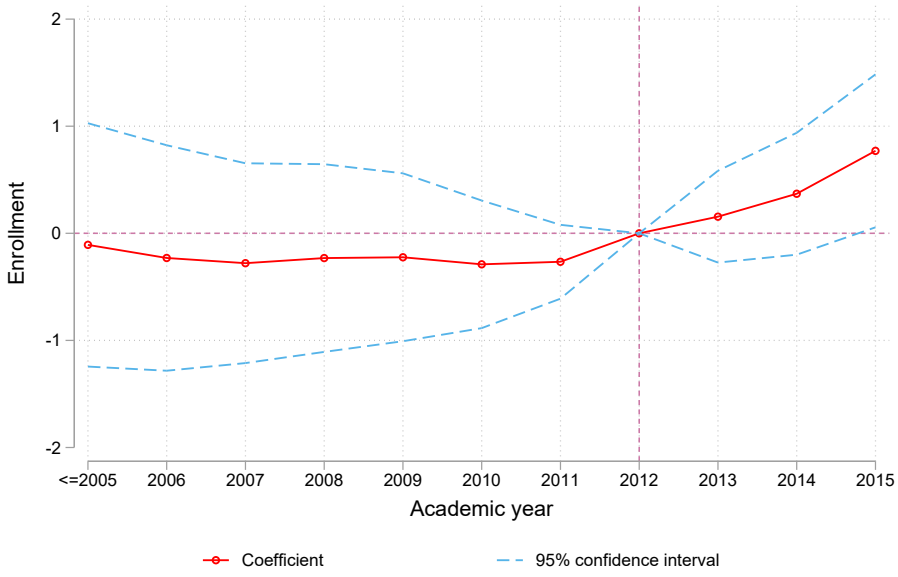


Figure D7: Event study of effect of U.K. policy change on new U.S. international enrollment from non-former British colonial countries - Master's Degree

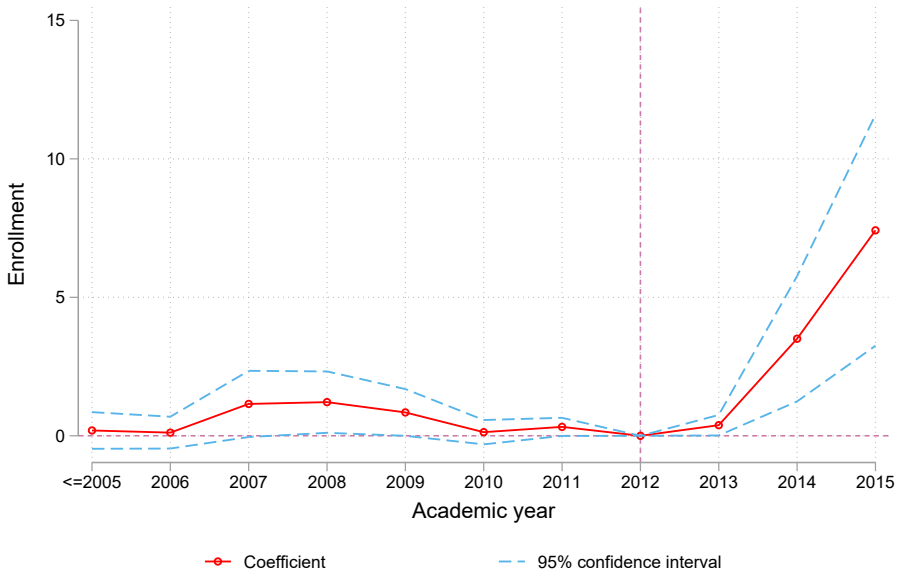


Figure D8: Event study of effect of U.K. policy change on new U.S. international enrollment from former British colonial countries - Master's Degree

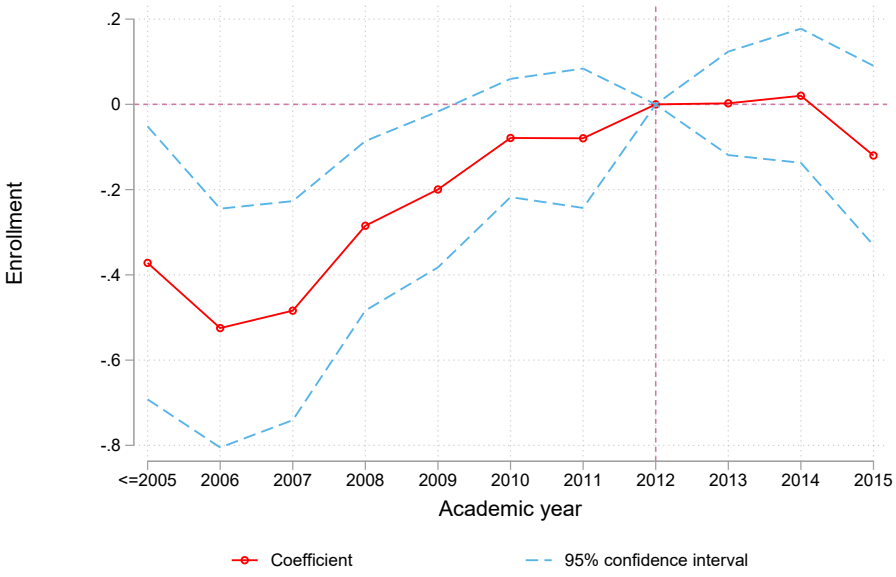


Figure D9: Event study of effect of U.K. policy change on new U.S. international enrollment from non-former British colonial countries - Doctorate Degree

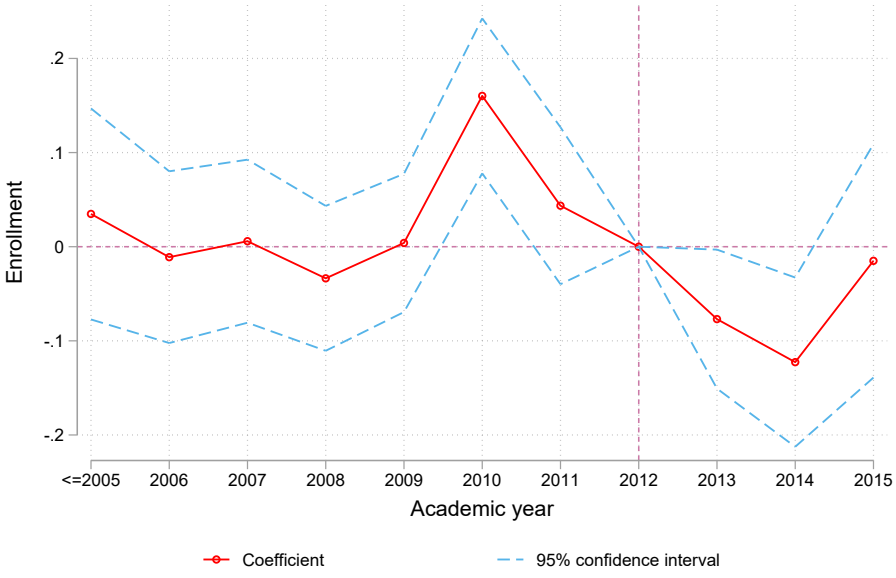


Figure D10: Event study of effect of U.K. policy change on new U.S. international enrollment from former British colonial countries - Doctorate Degree