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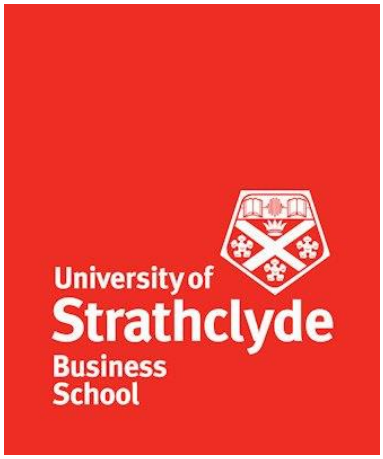

International Student Applications in the United Kingdom After Brexit

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Abstract

On June 23, 2016, the people of the United Kingdom voted to leave the European Union. We examine how Brexit impacted international student applications. Using administrative data spanning from 2013 through 2019, along with a quasi-experimental approach, we find that Brexit curtailed the growth rate of international student applications by seven percent even before tuition fees had changed, ultimately lowering enrolments as well. The impact is larger for applications to pursue STEM studies and for those from countries with worse employment prospects and weaker economies, suggesting students' ability to stay long-term in the United Kingdom was a critical pull factor.

JEL Codes: F22, I20, O15, I28, J61.
Keywords: Brexit, international student applications, college education, United Kingdom.

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"*No reference to immigration appeared on the ballot paper, but politicians believe that the Brexit vote represented a desire to "take back control" of the country's borders."* In "Keep Out: Lower immigration could be the biggest economic cost of Brexit", *The Economist*, February 25, 2017.

1. Introduction

On June 23, 2016, the people of the United Kingdom voted to leave the European Union (EU) – henceforth Brexit. In March 2017, the UK Parliament confirmed the result of the referendum. The European Union (Notification of Withdrawal) Bill passed by Parliament received Royal Assent and became an Act of Parliament. In accordance with Article 50(2) of the Treaty on European Union, the British Prime Minister Theresa May formally notified the European Council of her intention to withdraw from the EU, launching an exit negotiation process that ended in January 2020. One of the hallmarks of the EU is the free movement of people and labor between member countries. Brexit implied an eventual end to this mobility, to the right to settle in Britain, and to the right to bring family members for most European migrants, even if policies somewhat differed for low- vs. high-skilled migrants (Anderson, 2017).

Britain's split from the EU changes its relationship to the bloc on trade, security and, importantly, migration. Brexit raises the cost of studying in the United Kingdom by modifying EU students' home fee status,[1] the ability to secure loans,[2] and visa requirements.[3] Crucially, Brexit increases uncertainty regarding international students'

[1] This is the most immediate implication of Brexit for most EU students. Up until now, they enjoyed the same tuition fees as British students. At public universities in England, tuition at the undergraduate level was capped at 9,250 GBP/year; in Wales, at 9,000 GBP/year; and in Scotland, it was basically free for all UK and EU students. From 1 August 2021 onwards, these benefits will only apply to UK students. Students from EU country members will pay tuition fees up to two, three, or even four times higher, depending on the university (https://www.mastersportal.com/articles/2843/uk-tuition-fees-for-eueea-students-in-2021-changes-after-brexit.html).

[2] International students from EU country members and Switzerland will no longer be able to apply for student loans from August 2021 onwards. The program would cover tuition fees up to 9,250 GBP/year –the tuition limit for undergraduate studies. The money would go straight to the university and students would repay it in instalments, but only after reaching a certain income threshold (https://www.mastersportal.com/articles/2843/uk-tuition-fees-for-eueea-students-in-2021-changes-after-brexit.html).

[3] Brexit also modified the free movement of people that enjoyed EU members. Nevertheless, the Home Office has announced a new post-study Graduate immigration route intended to be launched on 1 July 2021. Full details

ability to pursue multiple degrees in the UK now that the cost is higher,[4] or to stay in the country to live and/or work after completion of their studies. This higher implicit economic cost could deter prospective students from considering studying in the United Kingdom in the first place. Finally, aside from the higher cost of pursuing a UK education, Brexit could also deter prospective students from moving to a country they feel is no longer welcoming migrants (Falkingham *et al*., forthcoming). We assess how a unique institutional change, such as the UK's decision to withdraw from the EU, has affected international student applications in the country. The outcome of the referendum on Brexit, where England (but not London) and Wales voted in favor to exit the bloc, whereas Scotland and Northern Ireland voted otherwise,[5] was unexpected.[6] As such, Brexit provides an ideal quasi-natural experimental setting enabling us to explore how the decision to leave the EU affects international students' decision to apply and enroll at a UK university.

Figure 1 shows international student applications to UK universities from the EU and non-EU block from 2007 through 2019. While both exhibit a somewhat parallel upward trend from 2008 through 2011 (before the increase in tuition fees in 2012 dampened EU applications) and from 2012 through 2016, international student applications from EU countries dropped in 2016 and stagnated thereafter whereas applications from non-EU countries rose by 18 percent. Using administrative data from the Universities and Colleges Admissions Service (UCAS) and a difference-in-difference approach,[7] we compare changes in international student applications from EU member

on the application process are still to be confirmed. However, the post-study visa will enable international students to work or look for work after their undergraduate studies for two years, or three years for PhD students (https://www.internationalstudents.cam.ac.uk/graduate-immigration-route).

[4] Many international students come to the UK with the intention to pursue both undergraduate and graduate studies: 25% of international students who graduated from a UK university in the academic year 2017/2018 reported to be enrolled in full- or part-time study 15 months after graduation (HESA, 2020). For them, the increased uncertainty surrounding the ability to finance those degrees might be substantial.

[5] The referendum about leaving the EU took place on March 23, 2016, and 51.9 percent of voters were in favour of leaving the EU (https://data.gov.uk/dataset/be2f2aec-11d8-4bfe-9800-649e5b8ec044/eu-referendum-results).

[6] In December 2015, opinion polls showed a clear majority in favour of remaining in the EU (*e.g.* Duncan, 2016).

[7] UCAS is a UK-based organization whose main role is managing applications to higher education courses in the UK. All students planning to study full-time for an undergraduate degree in England, Wales or Northern Ireland must apply through this system – including non-UK EU students and international students (non-EU). In Scotland, around a third

countries within source country, university, and subject of study to those from non-EU members, pre- vs post-UK's vote to leave the EU. International students from EU member countries constitute the *treatment* group, whereas international students from elsewhere make up the *control* group. The control group serves the purpose of netting out other changes taking place over the same period potentially affecting undergraduate applications of prospective international EU and non-EU students in alike ways.

We find that Brexit has significantly lowered applications originating from EU country members. Specifically, when compared to international student applications originating from elsewhere in the world, the growth rate of EU applications dropped by seven percent following the Brexit referendum. This effect, which proves robust to the use of various model specifications, dependent variable specification, and study samples, is not observed when we randomly draw the treatment group from the pool of non-EU countries in a placebo exercise. Additionally, we rule out anticipation effects and the existence of differential pre-trends in applications of EU vs. non-EU applicants. Changes in the volume of international student applications from the EU did not precede the Brexit referendum; rather, they occurred right after and persisted during the 3-year period that followed. Finally, the effect of Brexit has been similar across selective and less selective institutions of higher education, but has varied by subject of study, impacting more acutely sought-after international STEM applicants.

We also investigate some of the likely mechanisms at play focusing on the role of two key factors: (1) *psychological costs* resulting from a potentially unfriendly environment towards EU residents after Brexit, and/or (2) *economic factors* related to the now curtailed ability to stay long term in the United Kingdom upon completion of their studies to find employment. To assess the relevance of psychological costs in shaping student applications, we explore if Brexit had a differential impact across UK regions depending

of full-time undergraduate students is not included in UCAS figures –they mostly consist of full-time higher education students in further education colleges. These are colleges offering courses for people over the age of sixteen that provide university entrance qualifications, higher education-level diplomas and in some cases full Bachelor's degrees or more vocational courses combining school and university education with workplace experience.

on whether they voted to remain or to leave the EU. We find that the effect is homogeneous across areas that voted for or against Brexit. This finding suggests that concerns about the emergence of xenophobic sentiments, which could vary across regions depending on how they voted, might not have been the primary driver. Alternatively, international applicants might have been unaware of differences in Brexit voting patterns across UK regions. Next, we explore how the curtailed ability to stay long term in the United Kingdom after completing their studies and find employment might have influenced international student applications. To that end, we examine how applications vary based on economic conditions in the home countries of prospective students, as captured by their GDP per capita and employment to population ratios. International applications appear to have declined to a larger extent after Brexit among EU students from countries with lower per capita GDP and employment to population ratios –students who would have been more interested in staying in the United Kingdom after completion of their studies to live and work. Given that our sample is not yet subject to a change in tuition fees, we argue that these findings are suggestive of students' newly restricted employment prospects playing a critical role in explaining the decline in international applications after Brexit. In addition, given the negative effect of higher tuition fees on university applications in the past (Sa', 2019), the impact of Brexit on international student applications is likely to be higher for EU students when they no longer enjoy the lower fees paid by natives.

To conclude, we explore if the observed reductions in student applications had any implication for international student enrolments. Enrolments could remain unchanged if applications far exceeded admissions or if universities raised admission rates or provided incentives to EU applicants, such as fee waivers, to counteract a decline in student applications. Focusing on cells with non-zero applications, we find evidence of substantive drops in international student enrolments, underscoring concerns regarding the ability to attract international talent.

Understanding the diverse implications of Brexit is critical. In addition to potential trade and investment disruptions accompanying the undoing of 47 years of

economic integration, Brexit will end the free movement of people, affecting the right of people from elsewhere in EU to move to Britain and vice versa. This has created anxiety on the part of UK universities, which have increasingly relied on international applications. Specifically, the UK Department for Education has estimated their contributions to amount to £17.6 billion in 2015 (Migration Advisory Committee, 2018). As in the United States,[8] international students in the UK have been found to provide a vital source of income for the institutions where they study, cross-subsidising research and the education of domestic students, resulting in significant financial and creativity spillovers (Migration Advisory Committee, 2018).

Aside from innovation and fiscal considerations, demographic trends make this question particularly relevant considering the shrinking 18-years-old British population since 2017 (UCAS, 2017) –a trend potentially responsible for the recent decline in enrolments of UK students in undergraduate programs. General ageing of the UK population (ONS, 2017) makes attracting and retaining international students an important factor to sustain an aging society.

In sum, understanding the factors driving international student applications is key in ensuring student inflows and their positive externalities. This is especially relevant for a country such as the United Kingdom, which is second only to the United States in hosting international students (OECD, 2013). Before Brexit, international students represented 14 percent of undergraduate students and 35 of postgraduate students in the UK, and approximately 36 percent of international undergraduate students were EU nationals (HESA website).[9] Yet, to this date, we have no understanding of what the impact of Brexit will be on UK universities' ability to attract foreign talent.

This study contributes to a growing academic literature examining the determinants of student mobility and university applications. This literature

[8] See, for example, Hunt and Gauthier-Loiselle (2010), Stuen *et al.*, (2012), and Bound *et al.*, (2020).

[9] https://www.hesa.ac.uk/data-and-analysis/students/ (last accessed on June 4, 2021).

underscores the relevance of employment and earnings' aspirations in shaping international student applications (*e.g.* Bhagwati and Rao, 1999; Chiswick, 1999; Dustmann *et al*., 2011; Rosenweigz *et al*., 2006, among others), along with costs (Korn, 2017), and the availability of funding (Baer, 2017). More recently, the focus has turned to the role played by immigration policy, focusing on how H-1B visa caps in the United States have impacted on the quality of international student applicants and on enrolments (Chellaraj *et al*., 2008; Kato and Sparber, 2013; Shih, 2016; and Meckler and Korn, 2018). Less is known about similar policy impacts in the United Kingdom. The closest study to ours is one by Falkingham *et al.* (*forthcoming*), who examine how Brexit has impacted EU students' willingness to return home. Our focus is, instead, on students' willingness to apply to study in the United Kingdom in the first place, as well as on the type of applicant and the factors likely driving their choices.

More generally, the analysis improves our understanding of the implications of Brexit. Recent literature on Brexit has examined the determinants of the Brexit vote. Areas with low educational attainment and incomes, high unemployment, and a historically large concentration of employment in manufacturing were more likely to vote for Brexit (Becker *et al*., 2017). At the individual level, one of the main drivers were feelings about income rather than actual income (Liberini *et al*., 2019). Other studies have explored how Brexit impacted macroeconomic outcomes (*e.g.* Born *et al*., 2019; Breinlich *et al*., 2020), as well as public safety (*e.g.* Carr *et al*., 2020). Less has been done in terms of the impact of Brexit on universities. We address that gap by assessing how Brexit has impacted the volume, as well as the potential selectivity, of international applications. From a policy perspective, understanding the implications of Brexit on international student applications may prove crucial to safeguard universities from the loss of revenues as applications from within the United Kingdom have been declining. But, most importantly, it is vital in attracting international talent for innovation and growth.

2. Institutional Background

Before we dive into the analysis, it is worth making a few clarifications regarding higher education in the United Kingdom. It generally consists of three levels of courses leading to a degree: undergraduate degrees, Master's degrees, and Doctoral degrees (PhD). At the undergraduate level, there are different types of courses offered at universities and colleges, which are geared towards the following degrees, corresponding to different qualification levels in the national qualification framework:[10] Certificate of Higher Education and Higher National Certificate at level 4; Diploma of Higher Education, Higher National Diploma and Foundation degree at level 5, and a "first degree" or Bachelor's degree at level 6. All these courses are included in UCAS data.

The Certificate of Higher Education and Higher National Certificate are awarded after one year of full-time study at a university or other higher education institution, whereas the Diploma of Higher and Higher National Diploma are awarded after two years of full-time study and are equivalent to the first two-years of an undergraduate degree. The Foundation degree has the same entry requirements as a Bachelor's degree and is equivalent to the first two years of a three-year Bachelor's degree. Lastly, the Bachelor's or first degree is awarded after three or four years of study at a university or college.[11]

Prior to Brexit, international students from other EU country members enjoyed 'home fee status' in the United Kingdom. This meant they paid the same fees as British students. This implied significant savings with regards to the tuition fees paid by non-EU international students, often two to four times larger. In addition, EU students were able to apply for a student loan in England, Northern Ireland, or Wales, or have their fees paid by Student Awards Agency Scotland (SAAS) if they were studying as an undergraduate in Scotland. The loan, which typically amounted to the cost of

[10] These categorization and ranking apply to each UK region, although Scotland starts with level seven instead of level four.

[11] With the exception of Scotland, where a first degree lasts four years, typically in the rest of the United Kingdom it takes three years to finish a first degree.

undergraduate tuition, could be repaid in installments once working and their income reached certain thresholds. But, perhaps most importantly, students from other EU country members enjoyed the right to live and work in the United Kingdom upon completion of their studies without any restrictions.

Once Brexit was fully implemented –that is, after the transition period ending on December 31, 2020– conditions changed. EU students who arrived in the United Kingdom before January 1, 2021, are able to maintain the above conditions by applying for the so-called EU Settlement Scheme. EU students arriving after January 1, 2021, and starting their studies prior to July 31, 2021, experience changes in their immigration status, but are able to maintain the 'home status fee' that their counterparts enjoyed prior to Brexit. Lastly, those arriving after January 1, 2021 and starting their studies after July 2021, will not only experience a change in their immigration status, but also no longer enjoy the 'home status fee' of their predecessors. Each UK University will set its own fees for EU students. In addition, students will need to apply for a student visa if they are planning to stay for a course lasting beyond 6 months. This will require paying an application fee (£348) and having a current passport. The visa lasts two years if they are pursuing a course below degree level, and five years otherwise.[12] They will also need to pay an Immigration Health Surcharge (£470/year) that provides them with access to the UK National Health Service. Finally, unlike their predecessors, they might not be able to apply for a student loan in England, Northern Ireland or Wales, or have their fees paid by Student Awards Agency Scotland (SAAS) if they are studying as an undergraduate in Scotland.[13] While these provisions are still to be implemented and, as such, do not apply to EU applicants included in this analysis, the expectation of changing conditions (such as the ability to live and work in the United Kingdom after completing their studies or for those planning to continue studying after the undergraduate studies) might have impacted the decision to apply to the United Kingdom of many EU prospective students.

[12] The visa can be extended for those eligible –a process that implies an additional payment of £475 (see: Student visa : Extend your visa - GOV.UK (www.gov.uk)).

[13] For more information, please visit: https://study-uk.britishcouncil.org/moving-uk/eu-students.

3. Conceptual Framework

To better illustrate how Brexit might have impacted applications from EU students to study in the United Kingdom, we consider a simple model in which EU students primarily make that decision based on their perceived ability to stay in the United Kingdom to live and work after completing their studies. As noted earlier, in addition to any new application and health fees, Brexit modifies EU students' ability to stay long term in the United Kingdom –a change that might have deterred these students from applying to a UK university.

As in Kato and Sparber (2013), who model the response of international student applications to a reduction in the H-1B quota in the United States, we assume that, when deciding whether to study in the United Kingdom, EU students compare the expected net benefit from doing so in terms of labor market prospects upon graduation (p^*NB_i) to their reservation wage of studying elsewhere (RW_i) –both of which depend on students' skill levels (s_i). For simplicity, we assume zero migration costs, and p stands for the probability of finding employment and being able to stay long-term in the United Kingdom. Students will apply to study in the United Kingdom only if: $[p * NB(s_i)] > RW(s_i)$. We argue that Brexit will likely have two effects. First, Brexit should lower p,[14] as EU students' ability to find work and stay long-term in the United Kingdom after completing their studies should be somewhat restricted after Brexit.[15] Second, by raising tuition costs, eliminating the possibility of securing student loans, and imposing visa application costs, Brexit would be expected to also lower the net benefit (NB_i) associated to studying in the United Kingdom. Hence, when comparing the expected net benefits to the reservation wage for pursuing studies abroad, our *primary hypothesis* is that, via

[14] We could also allow p to be skill dependent. Either way, the overall impact of Brexit would be negative across the whole skill distribution, although to different degrees for various skill groups. Because the data do not allow us to test for heterogenous effects by entry-level skill, we do not introduce this possibility in the conceptual framework.

[15] Even though students in our sample would not have been yet impacted by the visa requirements established under the new points-based immigration system introduced on January 1, 2021, their expected probability of being able to stay long-term in the country after completing their studies after Brexit would have to be lower.

these two channels, Brexit might reduce the number of applications received from EU students, *ceteris paribus*.[16]

A *secondary hypothesis* is that such impacts might be heterogeneous, possibly varying across academic institutions, depending on their selectivity, as well as by subject areas.[17] A priori, it remains ambiguous how the average quality of applicants might change. If positively selected applicants are more sensitive to policy changes than other applicants, either because they tend to be better informed, have more options to study elsewhere, or because they were already the sole ones finding employment in the United Kingdom upon graduation, we might expect a decline in the average quality of applicants. Nevertheless, if less positively selected applicants were finding employment in the United Kingdom upon graduation prior to 2016, and Brexit only induces employers to seek employment visas exclusively for positively selected graduates, positively selected applicants might not be particularly hurt by the restrictions imposed by Brexit on their ability to stay long term in the United Kingdom upon graduation. Rather, the brunt of the policy might fall upon applicants on the left-tail of the ability distribution, who now will find it rather difficult to stay upon completion of their degrees –although a recently announced post-graduation visa should mitigate that impact by allowing graduates to stay for an additional 2–3-year period to find work in the future. Likewise, if universities provide financial incentives to high-quality applicants to compensate for the burdens imposed by Brexit, we might not observe any marked differences in the impact of Brexit across more vs. less selective academic institutions – even if highly qualified students proved more responsive to Brexit having other attractive options elsewhere. Usually, heterogeneous impacts by applicant's quality would be best examined with individual level information, such as entry level grades.

[16] The model assumes institutions are not reducing tuition fees or loosening selection criteria amid Brexit to counteract its potentially negative impact. If that were the case, the estimated effect of Brexit on applications would be attenuated. In robustness checks, we experiment with including (university x year) fixed effects to help capture those changes in university practices.

[17] For instance, highly selective universities might be differentially affected by Brexit when compared to less selective institutions. In addition, some subject areas, such as STEM fields, might prove more resilient than others.

Unfortunately, this information is not included in our data.[18] However, we can differentiate between applications to more and less selective institutions of higher education, as well as between sought-after STEM and non-STEM students, to learn about differential policy impacts.

4. Data and Descriptive Statistics

We use administrative data from the Universities and Colleges Admissions Service (UCAS) on undergraduate applications to UK universities over the 2013 through 2019 period.[19] UCAS is the body that manages all applications to undergraduate courses in the United Kingdom. Scotland is an exception, as around a third of full-time undergraduate students is not included in UCAS figures. They are applicants to further education colleges providing university entrance qualifications, higher education-level diplomas and in some cases full Bachelor's degrees or more vocational courses combining school and university education with workplace experience. UCAS produced on request the number of applications by year, subject, institutions (university or college) and country of domicile.[20] For most courses in the United Kingdom, the deadline to apply is in January of the year when the course starts. For any course at the University of Cambridge and Oxford, and most courses in medicine, veterinary medicine/science, and dentistry, the deadline is in October of the year before the course starts.

The decision to apply to a UK institution is best measured by data on applications. After all, enrolments are the by-product of student applications, university admissions, and students' acceptance of university admissions. As such, it is feasible for enrolments to remain unchanged if the volume of applications far exceeds the volume of university

[18] UCAS data contain harmonized measures of entry level quality for UK students only.

[19] We check the robustness of our results to using a longer time series that starts in 2008 (see Column 2 in Table 3B). However, we focus the analysis on the period 2013-2019 to exclude the effect of legislation increasing tuition fees for home and EU students introduced in 2012. Sá (2019) shows that the increase in tuition fees reduced substantially university applications by comparing applications to UK universities in England, which was subject to the increase in fees, to applications in Scotland, which was not subject to the fee increase. Focusing on the period 2013-2019 also results in a balanced time window around the treatment year, 2016.

[20] For confidentiality reasons, each cell count is rounded to the nearest five. Cell counts of one and two are reported as zero. They only represent 0.03 percent of the estimation sample.

admissions, or if universities raise admission rates to counteract a decline in student applications. While we make use of data on acceptances to assess the consequences of declining student applications on final student registrations,[21] our primary focus is on applications. Specifically, we use data on the total number of applications by country of origin of international applicants, institution, subject of study and year. Until 2007, students could submit up to six applications. From 2008 onward, this number was reduced to five.[22]

To abstract from existing educational attainment trends, we compute growth rates in the number of applications–defined as the log difference in applications received over two consecutive years. Each cell is specified at the source country, university, subject, and year level to look at comparable applicants as we argue that these might be the levels over which we would expect Brexit to exert an effect. We create a panel of 538,070 cells, consisting of 208 countries, 293 universities and colleges, 25 subjects, and 7 years, by setting empty cells equal to zero. The panel is slightly unbalanced since some universities (18 percent) appear for the first time in our dataset after the initial year; nevertheless, they represent only one percent of the sample.[23] To retain cells with a value of zero, we use the inverse hyperbolic sine transformation throughout. Gelber (2011) adopts a similar transformation in a different context. Table 1 provides a bird view of changes in international student applications.[24]

Despite our focus on a balanced and narrower time window around treatment spanning from three years prior to three years after the Brexit vote (*i.e.* from 2013 to 2019), Table 1 reports the time series spanning from 2008 onward to justify our sample choice. *First*, we observe that there was a significant increase in the volume of EU students

[21] According to the definition provided by UCAS, this variable refers to the number of applicants who have accepted an offer from a university. As these figures might not coincide with final enrolment, we also validate our analysis using enrolment data from the Higher Education Statistics Agency (HESA), the official administrative data on first year undergraduate students enrolled at a UK university.

[22] Our analysis is not affected by this rule change as our sample does not include pre-2008 years.

[23] For each university, we retain only the years after the first appearance in the dataset. Results are virtually unchanged if we entirely exclude these universities from the estimation sample.

[24] Each cell is weighted by the number of applications by country in the initial year to account for the fact that some countries, such as China, send significantly more students.

applying to UK universities after 2008 up until 2011, possibly in response to the unfolding Great Recession, which lowered the opportunity cost of pursuing tertiary education. This increase was much less pronounced for non-EU students, since the vast majority originated from China – one of the countries least affected by the Great Recession.[25] *Second*, applications from EU students dropped substantially in 2012 following the large increase in tuition fees from an average of £3,375 to approximately £9,000 per year, which affected UK and EU students with some differences across UK regions (Sá, 2019).[26] *Third*, despite a reduction in applications from 2016 to 2017 among the comparison group (non-EU students), the largest decline in applications from EU students occurred between 2017 and 2018, following the referendum on Brexit. Given the differential impact of the 2012 tuition fee hike on applications of EU and non-EU students, we focus our attention on the period starting right after –namely, 2013-2019. This results in a balanced time window spanning from three years prior to three years after Brexit that, in addition, allows us to gauge the impacts of Brexit more precisely by narrowing the time window around treatment.

At the bottom of Table 1, we compute the difference in the growth rate of international applications between 2016 and the last year for which we have data (*i.e.* 2019) for students from an EU country member and for students from a non-EU country member. As shown therein, the rate of growth of international student applications from non-EU countries *grew* by 3.7 percentage points over that period, whereas it *declined* by 6.3 percentage points for international students from EU nations. As a result, vis-à-vis international student applications from non-EU countries, the growth rate of international student applications from EU countries declined by ten percentage points over the 2016 through 2019 period.

[25] The decrease between 2007 and 2008 is observed for both EU and non-EU countries and it is likely driven by the reduction in the maximum number of applications each student was allowed to submit from 2008 onward.

[26] The rise in tuition fee affected all universities in England, whereas Scottish universities, as well as Northern Irish students studying in Northern Ireland, were unaffected. Welsh students at any UK university had the fee costs fully paid by the Welsh Assembly.

5. Methodology

While revealing, the figures in Table 1 are descriptive. Given the quasi-natural experimental feature of Brexit, we rely on a difference-in-difference approach to examine changes in university applications of international students from EU and non-EU countries, pre vs. post the referendum on Brexit as follows:[27]

$$(1) \qquad Y_{c,s,u,t} = \alpha + \beta_1 Post_t * EU_c + \beta_2 EU_c + \gamma_s + \delta_u + \eta_t + \varepsilon_{c,s,u,t}$$

where: $Y_{c,s,u,t}$ is the log difference or growth rate in international student applications from country (c), for subject of study (s), at university (u) from year (t-1) to year t.[28] Working with growth rates enables us to address the fact that the volume of applications from any given country to an institution in a particular subject are likely to be correlated over time due to the existence of established programs and networking among students and institutions. The variable $Post_t$ is a dichotomous variable that equals one for the period after the Brexit referendum (from 2017 onward), and zero otherwise.[29] Similarly, the EU_c variable is a dummy equal to one if the data refer to international students from a country belonging to the EU bloc, and zero otherwise.

We are particularly interested in the coefficient β_1, which captures how international student applications from EU countries changed, relative to those of non-EU countries, from before to after the Brexit referendum. Equation (1) also contains subject of study and university-specific fixed-effects, which capture subject and university-specific time invariant factors in the data related to the popularity of a given university and/or area of study, as in the case of STEM fields in recent years. In addition, year fixed effects control for temporal variation in our outcome. In alternative model

[27] Due to their similarities, we compare international students from EU countries (our treatment group) to international students from non-EU country members (our control group). While these students might, ultimately, be impacted by the vacuum created by EU students, they are not directly affected by Brexit and, as such, their response should be, at best, of second order. In addition, we do not use British students as a control for two reasons: (1) notable differences between native and international students; and (2) the well-documented shrinkage of the 18-years-old British population since 2017 (UCAS, 2017), which we also observe in our data (see Table A in the Appendix) and has been deemed responsible for the recent decline in enrolments of UK students in undergraduate programs.

[28] Before first differencing, we apply the inverse hyperbolic sine transformation to retain zeros (see Gelber, 2011).

[29] Note this dummy is not included separately in the model since it is naturally collinear with the year fixed effects.

specifications, we experiment with including the size of the population aged 15 to 19 years in each source country every year to account for changes in the size of college-entry cohorts.[30] We estimate equation (1) by OLS and cluster standard errors at the country level to allow for within group correlation in standard errors (Bertrand *et al.*, 2004).

6. Brexit and International Applications to UK Universities

6.1 Main Findings

Table 2 reports the results from estimating three different specifications of equation (1). In column (1), we display the estimated impact from the benchmark specification reported in equation (1). In column (2), we include the size of the potential student cohort (aged 15-19) in the source country in any given year as an additional control.[31] Finally, in column (3), we take into the account the fact that growth rates might change more drastically when the initial volume of international students in a cell is relatively small vs. large. Therefore, we use the number of applications by source country in the initial year as a weight.

The estimated impact of the Brexit referendum on the growth rate of applications from EU students is consistently negative and statistically different from zero at one percent level in all specifications. Focusing on the most complete and preferred model (column 3), the Brexit referendum resulted in a seven percent reduction in the growth rate of applications from EU students when compared to those from other international non-EU students. To place our finding in context, we compare it to the impact of the 2012 tuition fee increase. Column 1 in Table B in the Appendix displays the estimated impact of Brexit on applications using our sample of non-UK applications and the model specification used to examine the effect of Brexit to, instead, gauge the impact of the 2012 tuition fee increase affecting British and EU students, but not non-EU students. Brexit's

[30] Our analysis focuses on the period 2013-2019. The differential impact of higher tuition fees introduced in 2012 for EU students applying to universities in England, Wales, and Northern Ireland, which others have pointed out as a potentially important driver in explaining applications (Sà, 2019), would be captured by university fixed effects.

[31] This variable corresponds to the size of the population of age 15 to 19 and it is obtained from the World Bank Database (https://databank.worldbank.org/source/world-development-indicators).

impact would be equivalent to about one fourth of the effect of the 2012 tuition fee increase on applications from British students documented by Sà (2019). The results using our sample, reported in Table B of the Appendix, show that the tuition fee increase (approximately a 167 percent expansion) brought about a nine percent reduction in the growth rate of applications from EU students compared to non-EU students. Hence, Brexit would be equivalent to a 130 percent increase in tuition fees.

6.2 Identification and Robustness Checks

We conduct a series of robustness checks to further assess the reliability of our findings to the inclusion of additional two- and three-way fixed effects, and to the use of alternative samples. These are displayed in Tables 3A and 3B. Specifically, Table 3A shows the results from adding two- and three-way fixed effects. Column (1) displays our preferred estimates from Table 2, column (3), to serve as reference. Because our specification is the log difference of cells defined at the country-university-subject level between two consecutive years, the inclusion of two-way fixed-effects involving year-to-year variation at either the subject or the university level, as in columns (2) and (3) of Table 3A, naturally makes no difference on the estimated impact of Brexit. Similarly, the inclusion of three-way fixed effects capturing the year-to-year variation at the subject-university level in column (7) leaves the estimated impact of Brexit unchanged. A bit more interesting is the inclusion of two-way subject-university and university-country fixed effects in columns (4) and (5), respectively, as well as the inclusion of three-way subject-university-country fixed effects in column (6). Still, there is very little variation in the point estimates across these alternative specifications, suggesting that our results are not likely driven by the presence of confounders at the levels captured by those two- and three-way fixed effects' combinations.

To further assess if our results are driven by spurious correlations with unobserved factors, we also conduct a series of estimations that replace the treatment group with a placebo group constructed by randomly drawing 27 countries from the pool of non-EU countries each time. Figure 2 shows the distribution of the difference-in-

difference estimates resulting from such an exercise using 500 placebo replications, as well as the actual point estimate obtained from column (2) in Table 2.[32] We expect the actual estimate to fall in the far-left tail of the distribution of placebo estimates, as confirmed by Figure 2. The placebo point estimates are centered around zero and fall within a 95 percent confidence interval band around zero, suggesting they are not statistically different from zero. In contrast, the actual point estimate falls to the left and well outside the 95 percent confidence interval band, suggesting that the estimated impact in Table 2 is not the byproduct of spurious correlations.

Next, in Table 3B, we further assess the robustness of our findings to alterations of the estimation sample. As before, column (1) in Table 3B shows our preferred estimates from Table 2, column (3), to serve as reference. Next, in column (2), we estimate our preferred specification using the larger dataset reported in Table 1 (2008-2019). As shown therein, while the effect reasonably drops as we extend the pre-Brexit period from three to eight years, we still observe a statistically significant and substantial reduction in the growth rate of international student applications from EU countries by approximately 5.5 percent post-Brexit. Subsequently, in column (3), we experiment with excluding the first year of our sample –namely, 2013, which coincided with the year following the 2012 tuition fee increase. As shown therein, the estimated impact of Brexit would be somewhat higher, lowering the growth rate of applications by nine percent. In column (4), we experiment with excluding London from our sample of study. London can be considered a special market for university students and less sensitive to Brexit. The point estimate remains practically unchanged, with Brexit reducing the growth rate of international applications from EU countries when compared to international applications from elsewhere, by seven percent. Finally, in the last two columns, we display the results when we exclude top senders of international students to the UK. First, we experiment with excluding China. As shown by the estimate in column (5), results prove remarkably robust. Subsequently, we repeat the analysis excluding the top

[32] Because we are working with cells, as opposed to individual records, we refrain from using weights in this placebo exercise. Accordingly, the estimate corresponds to that in column (2) of Table 2.

five senders of international students to UK universities. As shown by the estimates in column (6), if anything, the impact of Brexit slightly rises. Brexit lowers the growth rate of EU applications by 11 percent when compared to applications from other international students, ruling out that our findings are driven by simultaneous changes happening in large sending countries.

To conclude, we conduct an event-study type analysis to gauge the validity of the parallel trend assumption in applications from EU and international non-EU students prior to the Brexit referendum, as well as to gauge potential dynamic effects. To that end, we explore trends in international student applications three years prior and three years after the Brexit referendum, as follows:[33]

$$(2)\quad Y_{c,s,u,t} = \alpha + \sum_{t=2013}^{2019} \beta_{1,t} Year_t + \beta_2 EU_c + \sum_{t=2013}^{2019} \beta_{3,t} (Year_t * EU_c) + \gamma_s + \delta_u + \varepsilon_{c,s,u,t}$$

Each coefficient $\beta_{3,t}$ should be interpreted with respect to the year 2016, the year when the referendum took place, which is the omitted interaction term. Figure 3 shows the coefficient estimates for the treatment-year interaction terms (also reported in Table D in the Appendix) along with their 95 percent confidence intervals. The estimates for the three years preceding the referendum are not distinguishable from zero, supporting the assumption of no pre-trends, the suitability of international students from non-EU countries as a control group, and the lack of anticipation effects –consistent with the unexpected nature of the referendum results. In addition, there is a clear break in the trend in applications from EU students surrounding the referendum –a trend that prevails during the three successive years. The persistence of the plotted negative impact is suggestive of EU students' preference to pursue their studies in the United Kingdom significantly changing on account of Brexit.[34]

[33] For consistency with our preferred specification, we control for the size of the population of age 15 to 19 in the source country by year and use the number of applications by country in the initial year as a weight.

[34] Figure A in the appendix replicates the analysis in Figure 3 using data on applications received through the beginning of 2020, which should have been largely unaffected by the COVID-19 pandemic. As can be seen therein, the impact of Brexit on applications from international students in the EU was not short-lived. We prefer not to use these data as our main sample as COVID-19 might have affected applications from China, where the pandemic was first discovered in the fall of 2019.

7. Heterogeneous Impacts

Thus far, the empirical evidence points to Brexit significantly curtailing applications to UK universities from EU students. As noted in the conceptual framework, Brexit might have also had a differential or heterogenous effect across universities, based on their selectivity, and across subject areas. Columns (1) and (2) assess if that appears to have been the case, distinguishing between applications to more vs. less selected universities.[35] Brexit appears to have lowered the growth rate of EU applications to selective universities by 7.5 percent and by close to 7 percent among those applying to less selective universities. While slightly greater among selective institutions, the difference is not statistically different from zero, suggesting that international student applications have been similarly impacted by Brexit at both selective and non-selective higher education institutions. As noted earlier, this could be the case if institutions foreseeing a significant drop in applications after Brexit offer financial incentives to applicants, for example.

Next, we look at whether the impact of Brexit appears to have differed across subject areas. Of particular interest are students applying to STEM programs, which have received much attention from policymakers in response to increased industry labor demands for that type of labor.[36] These sought-after students might be enticed to pursue their studies in countries where their future employment prospects have not been hindered by a recently curtailed ability to remain in the country upon completion of their studies. The analysis in columns (3) and (4) of Table 4, Panel A, tests if that appears to have been the case. Based on the estimates therein, Brexit appears to have had a larger

[35] Selective universities are defined according to the Russell Group, which includes 24 universities: University of Birmingham; University of Bristol; University of Cambridge; Cardiff University; Durham University; University of Edinburgh; University of Exeter; University of Glasgow; Imperial College London; King's College London; University of Leeds; University of Liverpool; London School of Economics & Political Science; University of Manchester; Newcastle University; University of Nottingham; University of Oxford; Queen Mary, University of London; Queen's University Belfast; University of Sheffield; University of Southampton; University College London; University of Warwick; and University of York.

[36] For example, in the United States, the Department of Homeland Security favoured the extension of the optional practical training (OPT) program –designed to provide international students with work experience in their fields– for students graduating in STEM fields through various reforms in 2008, 2011 and 2012. The reforms tried to accommodate increasing industry demands for STEM workers, who have been shown to boost local earnings and productivity (*e.g.* Moretti, 2004a, 2004b; Kantor and Whalley, 2014; Peri, Shih and Sparber, 2015).

impact on the growth rate of EU applications in STEM (ten percent reduction) when compared to non-STEM (five percent drop).[37] As indicated by the *p*-values of the difference between groups, we can reject the null hypothesis of both estimates being equal. Furthermore, based on the estimates in Panel B of Table 4, applications to life sciences,[38] engineering, computer science, and medicine dropped between 13 and 15 percent following Brexit, bearing the brunt of the referendum's vote outcome.

In sum, Brexit has not only cut down the volume of international student applications across all institutions of higher education –selective and less selective but, in addition, it has disproportionally impacted students in STEM fields. The disparate impact on this group of international students can have significant economic implications, given the documented positive externalities of STEM labor on local earnings and productivity (*e.g.* Moretti, 2004a, 2004b; Kantor and Whalley, 2014; Peri, Shih and Sparber, 2015) and its importance for innovation and growth –both, elsewhere (*e.g.* Hunt and Gauthier-Loiselle, 2010; Stuen *et al.*, 2012) and in the UK (Migration Advisory Committee, 2018).

8. Mechanisms and Enrolment Implications

To conclude, we explore potential mechanisms at play, to then investigate if the observed reduction in applications ultimately translated into lower international enrolments. First, we focus on two potential determinants of changes in the volume of international student applications following Brexit: (1) *psychological factors* embodied in student perceptions of how pleasant their experience abroad might be, and (2) *economic factors* exemplified in student perceptions of what their chances to find employment in the United Kingdom might be after completing their studies. Both factors have been

[37] We follow the Joint Academic Coding System (JACS) definition of STEM subjects, which includes: medicine; subjects allied to medicine; biological sciences; veterinary sciences, and agriculture science; physical sciences; mathematical sciences; computer sciences; engineering; technologies; architecture; building and planning; and combines sciences. Non-STEM subjects include: social studies; law; business and admin studies; mass communication and documentation; linguistics, classics and related; non-European languages, literature and related; history and philosophical studies; creative arts and design; education; combined arts; combined social sciences; social sciences combined with arts.

[38] This includes biological sciences, veterinary, and agricultural science. Results are virtually unchanged if we restrict the analysis to biological sciences.

shown to be key in explaining international student flows. For instance, Hazen and Alberts (2006) note how feelings of disaffection are among the most important reasons for international students to return home. The increase in xenophobic crime after the Brexit referendum would render support to that hypothesis (*e.g.* Devine, 2018; Carr *et al.*, 2020).

Similarly, the literature has documented how students' perceptions regarding their ability to work in the destination country after completion of their studies can impact international student enrollments. Focusing on the United States, Kato and Sparber (2013) show that H-1B visa restrictions have had an adverse impact on the quality of prospective international applicants, whereas Shih (2016) shows how a lower H-1B visa cap negatively impacted international enrolments.[39] In a similar vein, Bhagwati and Rao (1999), Chiswick (1999), and Rosenzweig (2006), among others, emphasize how international student applications are often tied to the prospect of securing employment in the destination country.

To gauge the potential role played by psychological factors, we examine if Brexit affected international student applications any differently in UK regions that voted to leave the EU, when compared to UK regions that voted to remain in the EU.[40] If international students fear the emergence of anti-immigrant sentiments in UK regions that voted to leave the EU, they might be less inclined to apply to universities in those regions, when compared to universities in other regions of the country. As can be seen in Panel A of Table 5, Brexit seems to have had a similar impact on EU student applications in both sets of regions, suggesting that the observed reduction was driven by reasons other than the friendliness of the environment to which students expect being exposed, or, alternatively, that students were not aware of different voting behavior across UK regions.

[39] H-1B visas are one of the most common channels for international students with an F-1 visa to work in the United States after completing their studies and any intermediate optional practical training period.

[40] As institutions based in London attract a very large share of applications (21 percent) and London voted for remain, on the contrary to England as a whole, we include London in the remain group.

Subsequently, we consider the role of other elements impacted by Brexit –such as EU students' ability to stay long-term in the United Kingdom after completing their studies. To that end, we investigate students' countries of origin, looking for traits reflective of the labor market and economic opportunities students might enjoy back home. We settle for two well-recognized and comparable traits: employment to population ratios and per capita GDP.[41] If a key determinant of EU student applications to UK universities is their ability to live and work in the United Kingdom after completion of their studies, we would expect to observe a greater reduction in applications from EU students originating from countries with worse employment and economic prospects. Those students would have been more likely to apply to a UK university with the hope of staying to live and work in the United Kingdom upon completion of their studies, when compared to students from countries with better economic and employment opportunities, who might understandably be more willing to return home.

Panels B and C in Table 5 explore the validity of the hypothesis stated above. In Panel B, we distinguish between students originating from countries with a GDP per capita that is above the median in that year and students from countries with a GDP per capita that is below that median.[42] In addition, we compare applications originating from countries in the top (75th percentile) and bottom (25th percentile) of the GDP per capita distributions each year. Next, in Panel C, we differentiate between students originating from countries with employment to population ratios for individuals 16 years of age and older that are below vs. above the median in that year, as well as between students from countries in the top 75th vs. the bottom 25th percentile of the employment to population ratio distributions.

[41] We obtain data on employment rate and GDP per capita from the World Bank – World Development Indicators Database, available at: https://databank.worldbank.org/source/world-development-indicators/ (last accessed on May 24, 2021).

[42] Median and percentile values are computed separately for EU and non-EU countries.

Brexit appears to have significantly lowered applications among students originating from countries with lower GDP per capita –by 11 percent for those from countries with rates below the median (column 2, Panel B) and by 20 percent for their counterparts from countries with rates below the 25th percentile (column 4, Panel B). Similarly, applications from EU countries dropped by 14 percent (column 2, Panel C) and 17 percent (column 4, Panel C) among students from countries with employment-to-population ratios below the median and below the 25th percentile, respectively. Yet, they either remained stable or dropped by much less (nine percent) among their counterparts from countries with employment-to-population ratios above the median or the 75th percentile, correspondingly.[43] Overall, the differential impact of Brexit on applications based on the source's country labor market and economic prospects points to the potential relevance of curtailed opportunities to live and work in the United Kingdom after completing their studies as a potential cause for the decline in applications.

To conclude, we explore the implications of Brexit on international student enrolments.[44] As noted earlier, while the drop in international student applications is worrisome, it is possible for Brexit to have no significant impact on final enrolments if, for example, applications far exceed admissions or universities raise admission rates to counteract a decline in student applications. Hence, using the same specifications as in Table 2, we estimate the impact of Brexit on the growth rate of international student enrolments. Table 6 displays the results from this exercise.

As with applications, results are rather consistent across the three model specifications. Focusing on our preferred model in column (3), we document a five percent reduction in international student enrolments after Brexit.[45] In other words, Brexit appears to have lowered international student applications enough to curtail enrolments. At the same time, given that the effect on enrolment is lower than the effect

[43] As indicated by the *p*-values, differences between the two sets of coefficient estimates were overall statistically different from zero.

[44] We are using acceptances as defined in UCAS data as a proxy for enrolment.

[45] Column 2 in Table C in the Appendix reports similar impacts if we use a log-level specification.

on applications (five vs. seven percent reduction), universities might have raised admission rates because of reduced applications. After all, enrolments are the byproduct of university offers and student acceptances. If, in accordance to their exhibited application patterns, students were not more likely to accept a university offer, the lower impact of Brexit among enrolments might be reflective of an increase in admission rates by universities. Either way, EU enrolments appear to have also dropped with Brexit.[46]

9. Summary and Policy Conclusions

We explore the impact that the 2016 Brexit referendum has had on international student applications from EU country members. Our findings suggest that students reacted strongly to the changing international environment, with the growth rate of applications declining by seven percent when compared to the growth of international applications originating from non-EU members. This effect, which appears robust to several robustness and identification checks, has affected similarly applications in selective vs. less selective institutions of higher education. Nevertheless, it has taken a larger toll on applications from students pursuing STEM studies in life sciences, engineering, computer science and medicine, suggesting these students might enjoy better alternatives elsewhere.

[46] As a robustness check, we repeat the analysis in Table 6 using HESA data on students enrolled at UK universities, that we obtain via Heidi-Plus. We have a slightly unbalanced panel of 539,318 cells, consisting of 232 countries, 160 universities and colleges, 18 subjects, and 7 years, that we obtain by setting empty cells equal to zero. Each cell represents the full person equivalent of enrolled full-time students by year, institution, country of domicile, and subject. The sample size is slightly bigger than the UCAS sample due to the smaller share of institutions entering after the initial year in the HESA sample. Therefore, we work with a balanced panel for most HESA providers. These two datasets are not entirely comparable due to differences in both coverage and methodology. Alternative providers are not included in this version of HESA data as the first year available for this sample is 2015, so we would not have enough pre-treatment data to estimate the Brexit effect for this sub-sample. Most providers included in the UCAS data and excluded from the HESA data are colleges, whereas HESA data includes a few conservatories excluded in the UCAS data. In addition, the recording of subjects studied by students undertaking a combination of courses differs across the two datasets. UCAS allocates students to a single major subject or a combination category, whereas HESA divides student numbers across the combination subjects. Despite these differences, the results from this exercise (displayed in Table E in the Appendix) generally corroborate our findings, with EU enrolments rates dropping anywhere between 4 and 6 percent, when compared to those from non-EU students, after Brexit. Note that the analysis on enrollment based on UCAS data considers enrollment *conditional* on positive applications in the respective cell. We are not able to provide the equivalent estimate with HESA data as there are no existing data on applications to which HESA enrollment data can be matched.

We also explore alternative mechanisms at play. *First*, we consider the possibility of EU students' perception of increased discrimination towards EU nationals in UK regions that voted to leave the EU. However, we find similar impacts of Brexit across UK regions, suggesting that psychological factors related to the welcoming environment students perceive in regions that voted to leave vs. to remain in the EU are not playing a decisive role in their decision to apply. *Second*, we explore the role that changing student incentives driven by diminished opportunities to work and live in the United Kingdom might be playing in their decision to apply to a UK university. We find that applications dropped the most among EU students originating from countries with lower per capita GDP and employment rates –students for whom the ability to live and work in the United Kingdom upon completion of their studies might have been an important pull factor. These findings point to deteriorating prospects as potential drivers behind EU students' application responsiveness.

Lastly, we investigate how changes in international student applications might have ultimately impacted international student enrolments. We find that the reduction in student applications resulted in fewer international enrolments –even though the reduction was not seemingly as large as the one observed for applications.

In sum, as free labor mobility disappears and employment opportunities shrink, EU students with potentially better alternatives –as in the case of STEM students– and fewer employment options back home significantly curtailed their applications. These students are those for whom the ability to live and work in the United Kingdom after completing their studies might have been an important pull factor to study in the United Kingdom. The documented impacts are worrisome. They are non-negligible, reducing enrolments despite universities' potential responses raising admission rates or increasing funding targeted to EU students. In addition, the results are suggestive of selective patterns affecting, in particular, STEM applicants –patterns that can have significant implications for innovation and economic growth (Migration Advisory Committee, 2018). Given the contributions of international student exchanges to research and development, as well as the United Kingdom's ranking as the second most frequent

destination for international students with a non-negligible 36 percent of them originating from EU country members (HESA website), further research on the implications of Brexit for UK universities and the ability to attract and retain valuable talent is well-warranted.

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Table 1
Growth Rate of Applications by Student Origin

Year	Non-EU	EU
2008	-0.123	-0.136
2009	0.029	0.136
2010	0.098	0.208
2011	0.090	0.065
2012	0.084	-0.201
2013	0.080	0.041
2014	0.053	0.057
2015	0.035	0.065
2016	-0.002	0.066
2017	-0.006	-0.084
2018	0.066	-0.002
2019	0.035	0.003
Difference 2019-2016	0.037	-0.063
DD	-0.10	

Notes: The table shows the growth rate in applications across two consecutive years by source country, subject, and university. The growth rate is computed by taking the first difference of the inverse hyperbolic sine transformation of applications by cell. Each cell is weighted by the number of applications by country in the initial year.
Source: UCAS.

Table 2
The Impact of Brexit on EU Applications

Column:	**(1)**	**(2)**	**(3)**
EUxBrexit	-0.084***	-0.081***	-0.071***
	(0.019)	(0.019)	(0.025)
DV Mean	0.032	0.033	0.033
Clusters	208	169	131
Observations	538,070	503,802	501,655
Population 15-19 in Source Country by Year	no	yes	yes
Weights	no	no	yes

Notes: The dependent variable is the growth rate in applications across two consecutive years by source country, subject, and university. The growth rate is computed by taking the first difference of the inverse hyperbolic sine transformation of applications by cell. Brexit refers to an indicator set equal to one for all years after 2016. Additional regressors include an EU dummy, subject, university, and year fixed effects. Each cell is weighted by the number of applications by country in the initial year. Standard errors in parentheses are clustered at country level. Significance levels are given by: * p<0.10, ** p<0.05, *** p<0.01.
Source: UCAS.

Table 3A: Robustness Checks #1 – Adding Two- and Three-Way Fixed Effects

Column:	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Model Specification:	**Reference**	**Subject-Year**	**University-Year**	**University-Subject**	**University-Country**	**Subject-University-Country**	**Subject-University-Year**
EUxBrexit	-0.071***	-0.071***	-0.072***	-0.071***	-0.066**	-0.066**	-0.075***
	(0.025)	(0.025)	(0.025)	(0.025)	(0.028)	(0.028)	(0.024)
DV Mean	0.033	0.033	0.033	0.033	0.033	0.033	0.033
Clusters	131	131	131	131	131	131	131
Observations	501,655	501,655	501,447	501,653	501,649	501,649	499,650

Notes: The dependent variable is the growth rate in applications across two consecutive years by source country, subject, and university. The growth rate is computed by taking the first difference of the inverse hyperbolic sine transformation of applications by cell. Brexit refers to an indicator set equal to one for all years after 2016. Additional regressors include an EU dummy, subject, university, and year fixed effects (when not included in the two- or three-way interaction), as well as the population 15-19 years old in the source country by year. Each cell is weighted by the number of applications by country in the initial year. Standard errors in parentheses are clustered at country level. Significance levels are given by: * p<0.10, ** p<0.05, *** p<0.01.

Source: UCAS.

Table 3B: Robustness Checks #2 – Using Alternative Samples

Column:	(1)	(2)	(3)	(4)	(5)	(6)
Model Specification:	**Reference**	**2008-2019**	**Excluding 2013**	**Excluding London**	**Excluding China**	**Excluding Top 5 Countries**
EUxBrexit	-0.071***	-0.055**	-0.090***	-0.074***	-0.071***	-0.113***
	(0.025)	(0.028)	(0.025)	(0.027)	(0.025)	(0.023)
DV Mean	0.033	0.034	0.028	0.034	0.033	0.036
Clusters	131	131	131	130	130	126
Observations	501,655	832,917	430,378	381,181	501,214	448,862

Notes: The dependent variable is the growth rate in applications across two consecutive years. The growth rate is computed by taking the first difference of the inverse hyperbolic sine transformation of applications by cell. Brexit refers to an indicator set equal to one for all years after 2016. Additional regressors include an EU dummy, subject, university, and year fixed effects, as well as the population 15-19 years old in the source country by year. All regressions are weighted by the number of applications by country in the initial year. Significance levels are given by: * p<0.10, ** p<0.05, *** p<0.01.
Source: UCAS.

Table 4: Heterogeneous Effects

Panel A: By University Selectiveness and Subject Area				
Column:	**(1)**	**(2)**	**(3)**	**(4)**
Group:	**Selective**	**Non-Selective**	**STEM**	**Non-STEM**
EUxBrexit	-0.075**	-0.068***	-0.103***	-0.047
	(0.036)	(0.023)	(0.025)	(0.028)
DV Mean	0.051	0.024	0.052	0.020
Clusters	130	131	129	131
Observations	165,984	335,671	219,462	260,390
p-value EUxBrexit	0.741		0.002	

Panel B: By Type of STEM Subject					
Column:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Group:	**Architecture**	**Life Sciences**	**Engineering-Computer Science**	**Medicine**	**Physics-Math**
EUxBrexit	0.067	-0.151***	-0.141***	-0.126***	-0.063
	(0.075)	(0.030)	(0.028)	(0.043)	(0.046)
DV Mean	0.007	0.082	0.063	0.041	0.045
Clusters	108	117	125	113	102
Observations	16,604	41,552	71,034	48,020	28,938

Notes: The dependent variable is the growth rate in applications across two consecutive years by source country, subject, and university. The growth rate is computed by taking the first difference of the inverse hyperbolic sine transformation of applications by cell. Brexit refers to an indicator set equal to one for all years after 2016. Additional regressors include an EU dummy, subject, university, and year fixed effects, as well as the population 15-19 years old in the source country by year. Each cell is weighted by the number of applications by country in the initial year. Standard errors in parentheses are clustered at country level. Significance levels are given by: * p<0.10, ** p<0.05, *** p<0.01.
Source: UCAS.

Table 5: Mechanisms

Perception of Anti-EU Sentiments at Destination		
Column:	**(1)**	**(2)**
Panel A: By UK Region	**Leave**	**Remain**
EUxBrexit	-0.074***	-0.066**
	(0.024)	(0.031)
DV Mean	0.036	0.027
Clusters	130	131
Observations	316,069	185,586
p-value EUxBrexit	0.670	

Economic Push Factors at Origin				
Column:	**(1)**	**(2)**	**(3)**	**(4)**
Panel B: By GDP in Origin Country	**Above Median**	**Below Median**	**>75 Pct**	**<25 Pct**
EUxBrexit	-0.042	-0.114***	-0.022	-0.199***
	(0.038)	(0.035)	(0.033)	(0.047)
DV Mean	0.024	0.045	0.008	0.034
Clusters	51	79	18	38
Observations	233,769	236,865	115,910	116,678
p-value EUxBrexit	0.183		0.001	
Panel C: By Emp Rate (16+) at Origin	**Above Median**	**Below Median**	**>75 Pct**	**<25 Pct**
EUxBrexit	-0.014	-0.144***	-0.091***	-0.173***
	(0.027)	(0.032)	(0.026)	(0.047)
DV Mean	0.022	0.052	0.018	0.070
Clusters	61	79	40	49
Observations	199,274	200,929	97,927	100,086
p-value EUxBrexit	0.003		0.100	

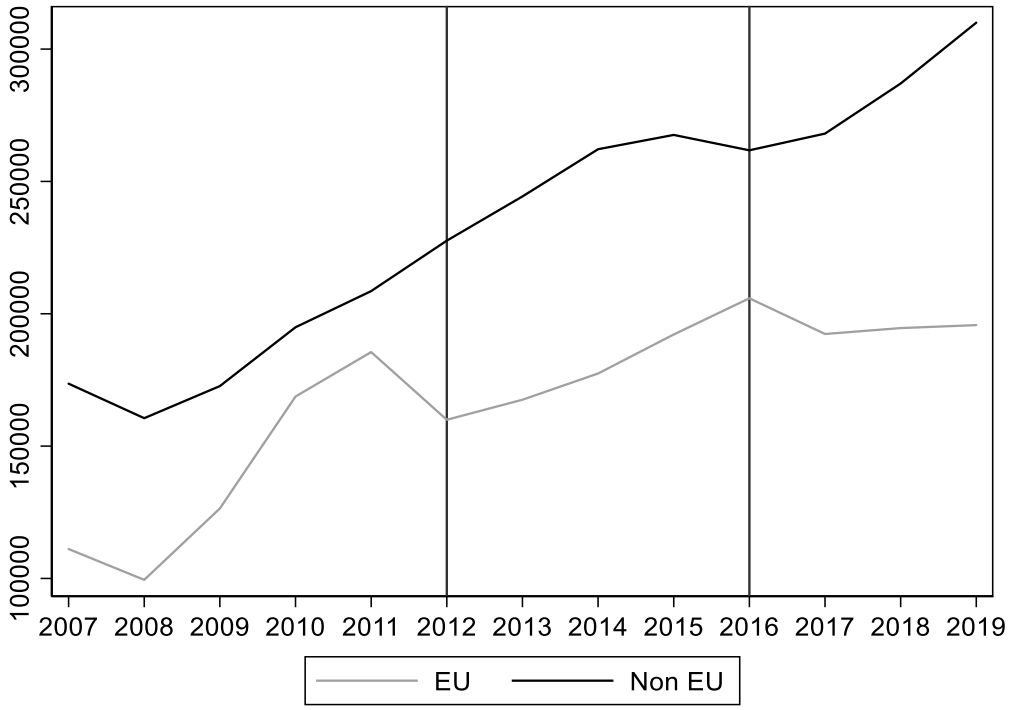
Notes: The dependent variable is the growth rate of applications across two consecutive years by source country, subject, and university. The growth rate is computed by taking the first difference of the inverse hyperbolic sine transformation of applications by cell. Brexit refers to an indicator set equal to one for all years after 2016. Additional regressors include an EU dummy, subject, university, and year fixed effects, as well as the population 15-19 years old in the source country by year. Each cell is weighted by the number of applications by country in the initial year. **Panel A** shows the results by UK region where the university is located. Column (1) shows the results for applications to UK universities in regions that voted to leave the EU, whereas column (2) refers to applications to UK universities in regions that voted to remain in the EU. **Panel B** shows the results by country-of-origin per capita GDP. Column (1) shows the results for applications from countries with annual GDP per capita above the median value, and column (2) does it for applications from countries with an annual GDP per capita below the median. Columns (3) and (4) refer to applications from countries with annual GDP per capita above the 75th percentile and below the 25th percentile, respectively. **Panel C** shows the results by country-of-origin employment to population ratio for individuals 16 years of age and older. Specifically, column (1) shows the estimated Brexit impact for applications from countries with employment rate above the median value in any given year, whereas column (2) does it for applications from countries with employment rate below the median value in any given year. Columns (3) and (4) refer to applications from countries with annual employment rate above the 75th percentile and below the 25th percentile, respectively. Median values and percentiles are computed separately for EU and non-EU countries. Standard errors in parentheses are clustered at country level. Significance levels are given by: * p<0.10, ** p<0.05, *** p<0.01.
Source: UCAS.

Table 6: Enrolment Implications Conditional on Applying

Column:	**(1)**	**(2)**	**(3)**
EUxBrexit	-0.047***	-0.046***	-0.053***
	(0.011)	(0.012)	(0.020)
DV Mean	0.016	0.016	0.016
Clusters	145	128	87
Observations	166,015	161,702	160,100
Population 15-19 in Source Country by Year	no	yes	yes
Weights	no	no	yes

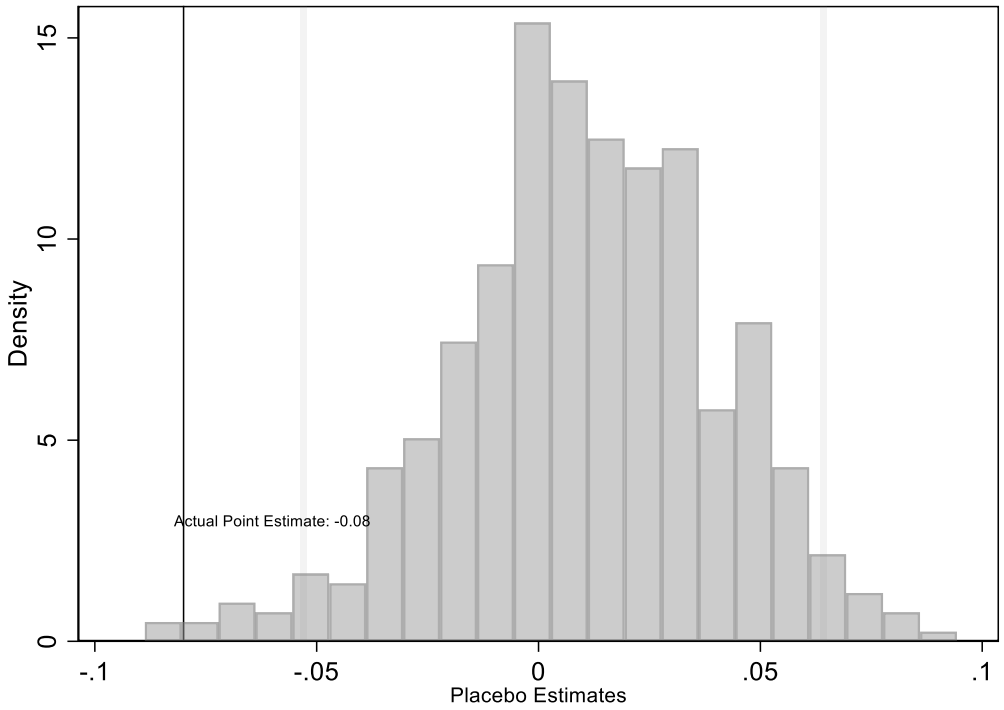
Notes: The dependent variable is the growth rate in enrolments across two consecutive years by source country, subject, and university. The growth rate is computed by taking the first difference of the inverse hyperbolic sine transformation of enrolments by cell. Cells with zero applications are discarded. Brexit refers to an indicator set equal to one for all years after 2016. Additional regressors include an EU dummy, subject, university, and year fixed effects. Each cell is weighted by the number of applications by country in the initial year. Standard errors in parentheses are clustered at country level. Significance levels are given by: * p<0.10, ** p<0.05, *** p<0.01.
Source: UCAS.

Figure 1
Total Applications by Student Origin and Over Time



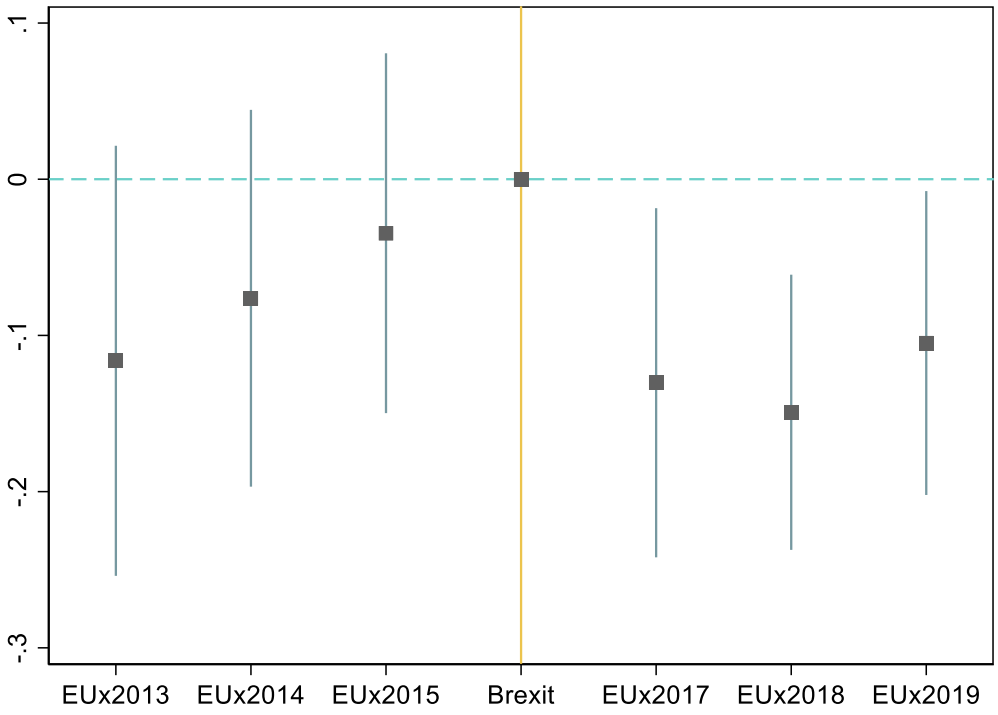
Notes: This figure shows total applications by EU vs non-EU group over time.
Source: UCAS.

Figure 2
Robustness Check: Histogram of Placebo Estimates



Notes: This figure shows the distribution of the coefficients obtained from 500 placebo regressions using our baseline specification (Table 2, column 2) and where the treated group has been randomly drawn from the group of non-EU countries. The dark vertical line refers to the actual point estimate reported in Column (2) of Table (2), whereas the two light grey lines refer to the 95% confidence interval.
Source: UCAS.

Figure 3
Treatment-by-Year Plot



Notes: The figure shows the coefficients of the interaction of leads and lags of the variable EUxYear, which is equal to one in the year indicated for EU applicants, and zero otherwise. The dependent variable is defined as in Table 2. The model specification is described in eq. (2). The growth rate is computed by taking the first difference of the inverse hyperbolic sine transformation of applications by cell. Additional regressors include an EU dummy, subject, university, and year fixed effects as well as the population 15-19 years old in the source country by year. Each cell is weighted by the number of applications by country in the initial year. Solid lines refer to regression coefficients, dotted lines refer to 95% confidence intervals obtained using clustered standard errors at country level.
Source: UCAS.

APPENDIX

Table A
Total Applications by British vs non-British

Year	Non-British	British
2008	260,020	1,862,010
2009	299,140	2,018,235
2010	363,650	2,290,580
2011	394,110	2,386,605
2012	387,595	2,173,885
2013	411,870	2,216,130
2014	439,620	2,299,960
2015	459,770	2,343,535
2016	467,625	2,344,800
2017	460,460	2,246,140
2018	481,605	2,153,925
2019	505,735	2,128,485
Difference 2019-2016	38,110	-216,315
% Change 2019-2016	0.081	-0.092

Notes: The table shows total applications by year and British vs non-British.
Source: UCAS.

Table B
Effect of 2012 Tuition Fee Rise

Column:	**(1)**	**(2)**
Sample:	**2008-2019**	**2008-2016**
EUxFee2012	-0.092**	-0.092**
	(0.039)	(0.042)
DV Mean	0.030	0.036
Clusters	131	131
Observations	731,176	546,983

Notes: The dependent variable is the growth rate in applications across two consecutive years by source country, subject, and university. The growth rate is computed by taking the first difference of the inverse hyperbolic sine transformation of applications by cell. Fee2012 refers to an indicator set equal to one for all years after 2011. Applications to Scottish universities are excluded as Scotland was not affected by the tuition fee raise. Additional regressors include an EU dummy, subject, university, and year fixed effects as well as the population 15-19 years old in the source country by year. Each cell is weighted by the number of applications by country in the initial year. Standard errors in parentheses are clustered at country level. Significance levels are given by: * p<0.10, ** p<0.05, *** p<0.01.
Source: UCAS.

Table C
The Impact of Brexit on EU Applications and Enrolments

Column:	**(1)**	**(2)**
Dependent Variable:	**Log (Applications)**	**Log (Enrolments)**
EUxBrexit	-0.110***	-0.044**
	(0.035)	(0.017)
DV Mean	1.262	0.432
Clusters	169	162
Observations	503,802	225,072

Notes: The dependent variable is the inverse hyperbolic sine transformation of applications by source country, subject, and university. Brexit refers to an indicator set equal to one for all years after 2016. Additional regressors include an EU dummy, subject, university, and year fixed effects, subject, university, and country time trends, and the population 15-19 years old in the source country by year. Standard errors in parentheses are clustered at country level. Significance levels are given by: * p<0.10, ** p<0.05, *** p<0.01.
Source: UCAS.

Table D
Treatment-by-Year Analysis of Brexit on EU Applications

EUx2013	-0.116*
	(0.070)
EUx2014	-0.076
	(0.061)
EUx2015	-0.035
	(0.058)
EUx2017	-0.129**
	(0.057)
EUx2018	-0.149***
	(0.044)
EUx2019	-0.103**
	(0.049)
Clusters	131
Observations	501,655

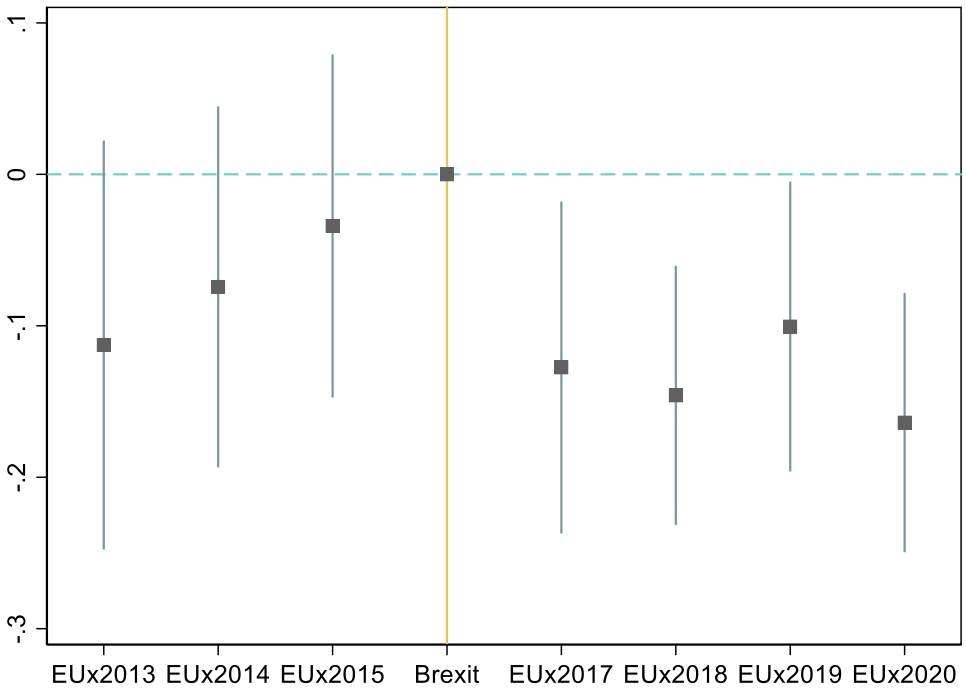
Notes: The dependent variable is the growth rate in applications across two consecutive years by source country, subject, and university. The growth rate is computed by taking the first difference of the inverse hyperbolic sine transformation of applications by cell. Leads and lags of EUxYear are equal to one in the year indicated for EU applicants, and zero otherwise. Additional regressors include an EU dummy, subject, university, and year fixed effects, as well as the population 15-19 years old in the source country by year. Each cell is weighted by the number of applications by country in the initial year. Standard errors in parentheses are clustered at country level. Significance levels are given by: * $p<0.10$, ** $p<0.05$, *** $p<0.01$.
Source: UCAS.

Table E
The Impact of Brexit on EU Enrolments using HESA Data

Column:	**(1)**	**(2)**	**(3)**
EUxBrexit	-0.037***	-0.037***	-0.060***
	(0.008)	(0.008)	(0.014)
DV Mean	0.016	0.017	0.017
Clusters	232	190	172
Observations	539,318	507,260	506,560
Population 15-19 in Source Country by Year	no	yes	yes
Weights	no	no	yes

Notes: The dependent variable is the growth rate in enrolments across two consecutive years by source country, subject, and university. The growth rate is computed by taking the first difference of the inverse hyperbolic sine transformation of enrolments by cell. Brexit refers to an indicator set equal to one for all years after 2016. Additional regressors include an EU dummy, subject, university, and year fixed effects as well as the population 15-19 years old in the source country by year. Each cell is weighted by the number of applications by country in the initial year. Standard errors in parentheses are clustered at country level. Significance levels are given by: * p<0.10, ** p<0.05, *** p<0.01.
Source: HESA.

Figure A
Treatment-by-Year Plot (2013-2020)



Notes: The figure shows the coefficients of the interaction of leads and lags of the variable EUxYear, which is equal to one in the year indicated for EU applicants, and zero otherwise. The dependent variable is defined as in Table 2. The model specification is described in eq. (2). The growth rate is computed by taking the first difference of the inverse hyperbolic sine transformation of applications by cell. Additional regressors include an EU dummy, subject, university, and year fixed effects, as well as the population 15-19 years old in the source country by year. Each cell is weighted by the number of applications by country in the initial year. Solid lines refer to regression coefficients, dotted lines refer to 95% confidence intervals obtained using clustered standard errors at country level.
Source: UCAS.