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Original Article

International student applications in the UK after Brexit

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Abstract

On 23 June 2016, the people of the UK voted to leave the European Union. This article examines how Brexit impacted international student applications. Using administrative data along with a difference-in-differences approach, we find that Brexit curtailed the growth rate of international student applications by 7 per cent even before tuition fees had changed, ultimately lowering enrolment as well. The impact is larger for applications to pursue STEM studies, as well as for those from countries with worse employment prospects and weaker economies, hinting on students' ability to stay long-term in the UK as an important pull factor.

Keywords: Brexit; international student applications; college education; United Kingdom

JEL classifications: F22, I20, I28, J61, O15

> *"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*, 25 February 2017).

1. Introduction

On 23 June 2016, the people of the UK voted to leave the European Union (EU)—henceforth Brexit. In March 2017, the UK Parliament confirmed the result of the referendum. After a lengthy negotiation process, in January 2020, the UK officially left the EU. 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- versus high-skilled migrants (Anderson 2017).

Britain's split from the EU changed its relationship to the bloc on trade, security and, importantly, migration. As predicted,[1] Brexit raised the cost of studying in the UK by modifying EU students' home fee status,[2]

[1] See, for example, https://www.theguardian.com/politics/2016/jun/03/brexit-vote-cost-uk-universities-tens-millions-student-fees-ucl.

[2] This was the most immediate implication of Brexit for most EU students. During the UK's membership in the EU, EU students 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 only applied to UK students. Students from EU country members had to 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).

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the ability to secure loans,[3] and visa requirements.[4] Yet, these impacts did not materialize until much later, that is, students applying to start their degrees after July 2021. Crucially, for EU students applying during the period we study, Brexit increased uncertainty regarding their ability to stay in the country to live and/or work after completing their studies. In addition, Brexit could have also deterred prospective EU students from moving to a country they felt was no longer welcoming migrants (Falkingham et al. 2021).[5]

We assess how a unique institutional change, such as the UK's decision to withdraw from the EU, impacted 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,[6] was unexpected.[7] 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—even though our analysis focuses on a narrower time window around treatment spanning from 2013 through 2019. While both groups of students exhibit a somewhat parallel upward trend after the increase in tuition fees in 2012 through 2016, international student applications from EU countries dropped in 2016 and stagnated thereafter. In contrast, applications from non-EU countries continued their upward trend. Using administrative data from the Universities and Colleges Admissions Service (UCAS),[8] along with a difference-in-differences approach, we compare changes in international student applications from EU member countries within source country, university, and subject of study to those from non-EU members, pre- versus post-UK's vote to leave the EU. International students from EU member countries constitute our *treatment* group, whereas international students from elsewhere make up our *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 students from the EU and elsewhere in alike ways, such as changing economic prospects in the UK or the changing quality of UK universities.

We find that Brexit significantly lowered applications originating from EU country members. When compared to international student applications originating from elsewhere in the world, the growth rate of EU applications dropped by 7 per cent 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 or artificially set the timing of Brexit to years prior in placebo exercises. Additionally, we rule out anticipation effects and the existence of differential pre-trends in applications of EU versus non-EU applicants. Finally, the impact of the referendum persisted during the 3-year period that followed and was similar across selective and less selective institutions of higher education, although it varied by subject of study, impacting more acutely sought-after international Science, Technology, Engineering, and Mathematics (STEM) applicants.

We also investigate two likely mechanisms at play: (1) *Psychological costs* resulting from a potentially perceived less welcoming environment toward EU residents after Brexit and (2) *Economic factors* mainly related to their expected curtailed opportunities to live and work in the UK after graduation. We fail to

[3] International students from EU country members and Switzerland are no longer be able to apply for student loans from August 2021 onwards. The program used to 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).

[4] 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 on the application process are still to be confirmed. However, the post-study visa is expected to 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).

[5] Other factors affecting international students' decision to study in the UK might have included a gloomy economic prospect in response to Brexit or even a changing quality of UK universities. Note, however, that these factors would impact both EU and non-EU applicants and, therefore, should be captured by year fixed effects.

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

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

[8] 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 of full-time undergraduate students are 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.

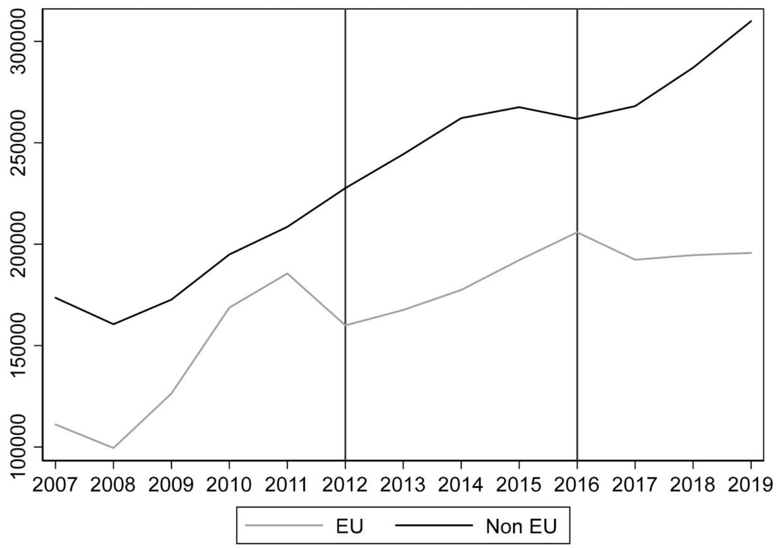

Figure 1. Total applications by student origin and over time.

Notes: This figure shows total applications by EU versus non-EU group over time. The two vertical lines are indicative of the timing of the tuition fee increases in 2012 and the Brexit referendum in 2016. Our analytical sample covers the period between 2013 and 2019.

Source: UCAS.

find any evidence of psychological costs, but student responses to Brexit conform with changes in their economic expectations—a finding congruent with the finding from Castro-Pires, Mello, and Moscell (2023) when examining the effect of the Brexit referendum on the share of EU nurses in English National Health Service (NHS) hospitals. Understanding student responses to Brexit is relevant. While enrolment impacts of changes to students' ability to stay long-term in host countries have already been examined in other settings (e.g. Shih 2016; Amuedo-Dorantes, Shi, and Xu 2022), an assessment of how Brexit may have impacted the educational sector is still missing.

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. We find evidence of substantive drops in international student enrolments, underscoring concerns regarding the ability to attract international talent.

Gaining further insight on the diverse implications of Brexit is important for various reasons. In addition to potential trade and investment disruptions accompanying the undoing of 47 years of economic integration, Brexit ended free movement of people, affecting the right of people from elsewhere in EU to move to Britain and vice versa. This created anxiety on the part of UK universities, which had increasingly relied on international applications. The UK is second only to the USA in hosting international students (OECD 2013). Before Brexit, international students represented 14 per cent of undergraduate students and 35 of post-graduate students in the UK, and 36 per cent of international undergraduate students were EU nationals (HESA 2020).[9] As in other countries,[10] international students provide a vital source of income for UK institutions (Migration Advisory Committee 2018).

This study contributes to a growing academic literature examining the relevance of employment and earnings' aspirations (e.g. Bhagwati and Rao 1999; Chiswick 1999, among others; Dustmann, Fadlon, and Weiss 2011), costs (Korn 2017; Beine, Delogu, and Ragot 2020), and the availability of funding (Baer 2017) in shaping international student applications and mobility. More recently, the focus has turned to the role played by immigration policy, focusing on how H-1B visa caps in the USA have

9 https://www.hesa.ac.uk/data-and-analysis/students/ (last accessed on 20 December 2022).

10 See, for example, Hunt and Gauthier-Loiselle (2010), Stuen, Mobarak, and Maskus (2012), or Bound et al. (2020) for studies focused on the USA.

impacted on the quality of international student applicants and on enrolments (Chellaraj, Maskus, and Mattoo 2008; Kato and Sparber 2013; Shih 2016; Meckler and Korn 2018). Less is known about similar policy impacts in the UK.[11] The closest study to ours is Falkingham et al. (2021), who examine how Brexit impacted the willingness of EU students in the UK to return home. Our focus is, instead, on students' willingness to apply to UK universities in the first place, as well as on the type of applicant and the factors likely driving their choices.

More generally, the analysis herein adds to our understanding of the implications of Brexit. While 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) and migration (e.g. Di Iasio and Wahba 2023), less is known about its impact on universities.[12] We address that gap by assessing how Brexit, which effectively ended the right of people from elsewhere in EU to move to Britain and vice versa after 47 years of guaranteed free movement of labor, affected the volume and selectivity of international applications.

2. Institutional background

Higher education in the UK 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 toward the following degrees, corresponding to different qualification levels in the national qualification framework[13]: 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 2 years of full-time study and are equivalent to the first 2 years of an undergraduate degree. The Foundation degree has the same entry requirements as a bachelor's degree and is equivalent to the first 2 years of a 3-year bachelor's degree. Last, the bachelor's or first degree is awarded after 3 or 4 years of study at a university or college.[14]

Prior to Brexit, international students from other EU country members enjoyed "home fee status" in the UK. This meant they paid the same fees as British students. This implied significant savings with regard 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 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 UK upon completion of their studies without any restrictions.

Once Brexit was fully implemented—that is, after the transition period ending on 31 December 2020—conditions changed. EU students arriving to the UK before 1 January 2021, were able to maintain the above conditions by applying for the so-called EU Settlement Scheme. EU students arriving after 1 January 2021, and starting their studies prior to 31 July 2021, experienced changes in their immigration status, but were able to maintain the "home status fee" that their counterparts enjoyed prior to Brexit. Lastly, those arriving after 1 January 2021, and starting their studies after July 2021, not only experienced a change in their immigration status, but also no longer enjoyed the "home status fee" of their predecessors.[15] In addition, since Brexit, students need to apply for a student visa if they are planning to stay for a course lasting beyond 6 months. This requires paying an application fee (£348) and having a current passport. The visa lasts 2 years if they are pursuing a course below degree level, and 5 years

[11] Other studies focused on the UK have examined, instead, crowding out of domestic students by international students (e.g. Machin and Murphy 2017).

[12] In addition, the literature on Brexit has examined the determinants of the Brexit vote, for example, Becker, Fetzer, and Novy (2017) and Liberini et al. (2019).

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

[14] Apart from Scotland, where a first degree lasts four years, typically in the rest of the UK it takes three years to complete a first degree.

[15] Each UK University sets its own fees for EU students.

otherwise.[16] EU students 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, EU students are not able to apply for a student loan in England, Northern Ireland, or Wales, or have their fees paid by SAAS if they are studying as an undergraduate in Scotland.[17]

While the above provisions were not yet in place during the timer period under study, the uncertainty regarding their ability to live and work in the UK after graduation might have impacted the decision to apply to the UK of many EU students.

3. Conceptual framework

To better illustrate how Brexit might have impacted applications from EU students to study in the UK, we consider a simple model in which EU students primarily made that decision based on their perceived cost of studying in the UK and their ability to stay in the UK to work after completing their studies. As in Kato and Sparber (2013), who model the response of international student applications to a reduction in the H-1B quota in the USA, we assume that, when deciding whether to study in the UK, EU students compared the expected UK return from doing so in terms of labor market prospects upon graduation ($p^{*}UK\ return_i$) to their reservation wage of studying elsewhere (RW_i)—both of which depended on students' skill levels (s_i). For simplicity, we assume zero migration costs, with p representing the probability of finding employment and being able to stay long-term in the UK. Students applied to study in the UK only if: $[p * UK\ return\ (s_i)] > RW(s_i)$. We argue that Brexit probably lowered p,[18] as EU students' ability to find work and stay long-term in the UK after graduation was curtailed.[19] Hence, our *primary hypothesis* is that Brexit might have reduced the number of applications received from EU students who compared the expected return from studying in the UK to the reservation wage associated with studying abroad.[20]

A *secondary hypothesis* is that the impact of Brexit might have been rather heterogeneous, varying across academic institutions, depending on their selectivity, as well as by subject areas. Highly and less selective universities may have been affected by Brexit differently. Likewise, STEM fields may have been impacted differently than other fields given that these are highly sought-after majors elsewhere. A priori, it remains ambiguous how. If less positively selected applicants were easily finding employment in the UK upon graduation prior to 2016, and Brexit induced employers to seek employment visas exclusively for positively selected graduates, the brunt of the policy may have fallen upon applicants on the left-tail of the ability distribution. However, if positively selected applicants were more sensitive to policy changes than other applicants—either because they were better informed, had better options to study elsewhere, or were already the ones primarily finding employment in the UK upon graduation, Brexit may have particularly reduced their applications. These impacts could have been watered down if universities provided financial incentives to compensate for the burdens imposed by Brexit.

Unfortunately, we lack data on individual entry level grades, which would prove ideal to examine heterogeneous impacts by applicant's quality. However, we differentiate between applications to more versus less selective institutions of higher education, as well as between sought-after STEM versus non-STEM students, to learn about differential policy impacts.

4. Data and descriptive statistics

We use administrative data from the UCAS on undergraduate applications to UK universities over the 2013 through 2019 period.[21] UCAS is the body that manages all applications to undergraduate courses

[16] 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)).
[17] For more information, please visit: https://study-uk.britishcouncil.org/moving-uk/eu-students.
[18] 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.
[19] 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 1 January 2021, it is reasonable to argue that their expected probability of being able to stay long-term in the country after completing their studies after Brexit may have diminished.
[20] 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 × year) fixed effects to help capture those changes in university practices.
[21] We check the robustness of our results to using a longer time series that starts in 2008 (see column (2) in Table 3D). However, we focus the analysis on the period 2013–19 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

in the UK. 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.[22] For most courses in the UK, 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 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,[23] 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; however, our analysis is not affected by this change since it does not include the period prior to 2008.

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 per cent) appear for the first time in our dataset after the initial year; nevertheless, our results remain unchanged when we exclude those universities as they represent only one per cent of the sample. To retain cells with a value of zero, we use the inverse hyperbolic sine transformation throughout (see Gelber 2011 for an application). Table 1 provides a bird view of changes in international student applications, where each cell is weighted by the number of applications from each country in the initial year.

Even though our analysis uses data from a balanced and narrower time window around treatment that spans from 3 years prior to 3 years after the Brexit vote (i.e. from 2013 to 2019), Table 1 reports on a longer time series to justify our sample choice. Several findings are worth discussing. First, there was a significant increase in the volume of EU students applying to UK universities from 2008 through 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.[24] 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—an increase that affected UK and EU students with some differences across UK regions (Sá 2019).[25] Third, 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, 2013–19. This results in a balanced time window

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 2013–19 also results in a balanced time window around the treatment year, 2016.

22 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 per cent of the estimation sample.

23 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 2020), the official administrative data on first year undergraduate students enrolled at a UK university.

24 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.

25 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.

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 2019–16	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.

spanning from 3 years prior to 3 years after Brexit that, in addition, allows us to gage 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.

5. Methodology

While revealing, the information in Table 1 is purely descriptive and fails to account for idiosyncratic university, subject of study, or temporal traits that might have impacted international student applications. To gage the potential impact of the Brexit referendum on international student applications to universities in the UK, we exploit the quasi-natural experimental feature of Brexit to examine changes in university applications of international students from EU and non-EU countries, pre versus post the referendum on Brexit adopting the following difference-in-differences specification[26]:

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

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. We apply the inverse hyperbolic sine transformation before first differencing to retain zeros (see Gelber 2011). 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 is 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.

[26] 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 A1 in the Appendix) and has been deemed responsible for the recent decline in enrolments of UK students in undergraduate programs.

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 changes in the growth rate of international student applications from EU countries, relative to those from 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 driven by macroeconomic shocks potentially impacting economic prospects for the UK, the value of the British pound, or the quality of UK universities. In alternative model specifications, we experiment with including the size of the population aged 15–19 years in each source country every year to account for changes in the size of college-entry cohorts.[27] Additional controls, including country of origin–year fixed effects, are included among our set of robustness checks. We estimate Equation (1) by OLS and cluster standard errors at the country level to allow for within group correlation in standard errors (Bertrand, Duflo, and Mullainathan 2004).[28]

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 years) in the source country in any given year as an additional control. Finally, in column (3), we consider the fact that growth rates might change more drastically when the initial volume of international students in a cell is relatively small versus 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 per cent level in all specifications.[29] Focusing on the most complete model specification (column (3), the Brexit referendum resulted in a 7 per cent reduction in the growth rate of applications from EU students when compared to those from other international non-EU students.[30] To place our finding in context, we compare it to the impact of the 2012 tuition fee increase. Columns (1) and (2) in Table A3 in the Appendix display the estimated impact of Brexit on applications using our sample of non-UK applications, as well as the shorter period ending before Brexit. Using the model specification in Table 1, we estimate the impact of the 2012 tuition fee increase affecting British and EU students, but not non-EU students. Regardless of the sample period being used, Brexit's 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, reported in Table A3 of the Appendix, show that the 2012 tuition fee increase from £3,375 to roughly £9,000 per year brought about a 9 per cent reduction in the growth rate of applications from EU students compared to non-EU students. Hence, Brexit would be equivalent to an additional 130 per cent increase in tuition fees from £9,000 to approximately £20,700 per year.[31]

6.2 Identification, robustness, and placebo checks

6.2.1 Identification checks

There are two critical identification assumptions in a difference-in-differences analysis. One refers to the possibility of differential pre-trends contaminating our estimates. To assess if this should be a concern in our case, we conduct an event-study type analysis to gage the validity of the parallel trends'

[27] Our analysis focuses on the period 2013–19. 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.

[28] While clustering at the EU/non-EU level may seem a natural choice, the literature advises against the use of a wild cluster bootstrap with very few clusters—a number identified as less than 12 (Webb 2023) or 42 (MacKinnon and Webb 2018). Doing so results in *P*-values that are not point identified (e.g. MacKinnon and Webb 2017, 2018; Webb 2023).

[29] This is also the case when using a log-level specification, as shown in column (1) of Appendix Table A2.

[30] Results prove robust to using country fixed effects, as opposed to the EU dummy variable, in Equation (1). Specifically, the EU×Brexit point estimate equals −0.065 and is significant at 5 per cent level, with standard errors equal to 0.028. Results are available from the authors upon request.

[31] It is worth pointing out that, if universities raised international fees for non-EU students over that period to ensure they remained above those paid by home students, the estimated impact of the tuition fee increase in Table A3 might represent a lower-bound estimate of the true impact of the tuition fee increase on applications. In turn, the estimated impact of Brexit may be equivalent to less than a 130 per cent increase in tuition fees.

Table 2. The impact of Brexit on EU applications.

Column:	(1)	(2)	(3)
EU × Brexit	−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: * $P<.10$, ** $P<.05$, *** $P<.01$.

Sources: (1) UCAS and (2) data on the size of the population of age 15–19 years from the World Bank Database (https://databank.worldbank.org/source/world-development-indicators).

assumption prior to the Brexit referendum, as well as to gage potential dynamic effects. To that end, we explore trends in international student applications 3 years prior and 3 years after the Brexit referendum, as follows:

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

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 2 shows the point estimates for the treatment–year interaction terms (also reported in Table A4 in the Appendix) along with their 95 per cent confidence intervals. The estimates for the 3 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 UK significantly changing on account of Brexit.[32]

For further reassurance about our findings, we also implement the methodology proposed by Rambachan and Roth (2023) for robust inference and sensitivity analysis when parallel trends may be violated. As noted by Roth (2022), the assumption behind these sensitivity checks is that there may be something to be learned even when the pre-treatment parallel trends assumption is violated, especially if the violation is not large. Rambachan and Roth (2023) suggest two approaches. The first one—henceforth, bounds on relative magnitude—estimates the magnitude of the post-treatment violation of the parallel trends' assumption, vis-à-vis the maximum pre-treatment violation, that would render the estimated impact inconsistent. The second approach—henceforth, smoothness restriction—estimates the magnitude of the violation from a linear extrapolation of the pre-treatment differences in trends that would render the estimated impact inconsistent. Figure A2 illustrates the parameter "M" that would render our estimates inconsistent according to these two approaches. The figure shows in blue the 95 per cent confidence interval of the treatment effect estimation corresponding to the first post-treatment year (2017). In red, it shows the 95 per cent confidence intervals allowing for violations of pre-treatment parallel trends up to parameter "M." Our estimated coefficient remains statistically significant even if we allow for violations of the parallel trends' assumption up to the maximum observed in the pre-period ($M=1$ as a bound for relative magnitude, Panel A) and up to a deviation of $M=0.02$ from the linear extrapolation of the estimated pre-trend (smoothness restriction, Panel B).

[32] Figure A1 in the Appendix replicates the analysis in Fig. 2 using data on applications received through the beginning of 2020, which should have been largely unaffected by the Coronavirus disease 2019 (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.

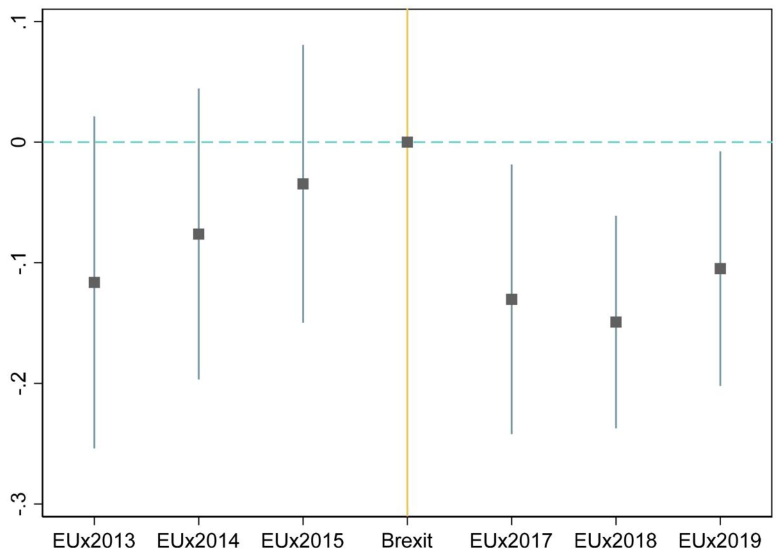

Figure 2. Treatment-by-year plot (2013–19)

Notes: The figure shows the coefficients of the interaction of leads and lags of the variable EU × Year, 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 Equation (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 per cent confidence intervals obtained using clustered standard errors at country level.

Sources: (1) UCAS and (2) data on the size of the population of age 15–19 years from the World Bank Database (https://databank.worldbank.org/source/world-development-indicators).

This deviation of M = 0.02 represents over 40 per cent of the average change in the pre-period slope, which is equal to 0.047. Collectively, the two approaches suggest that our results remain robust even if substantial deviations from the estimated pre-trends are considered. Together with the event study estimates, these results support the credibility of our findings.

In addition to the pre-treatment parallel trends' assumption, we also check on the Stable Unit Treatment Value Assumption (SUTVA). This assumption would be violated if the treatment has spill-over effects on the control or untreated group. In our case, this would occur if foreign-born applicants from outside the EU applied in greater numbers after Brexit. To address this challenge, we consider *two* counterfactual scenarios for applications from international students from outside the EU—both of which assume students from the EU did not increase their applications but, rather, continued to behave in the same way they had prior to the referendum. In the *first* scenario, we assume that non-EU international student applications experienced the same growth rate trajectory post-Brexit as they did prior to the referendum. To that end, we compute the yearly average growth rate in applications at the cell level before Brexit and apply that growth rate to compute the level of applications for international students from outside the EU after the referendum. Using those imputed levels, we compute the new growth rates for non-EU applications post-Brexit to re-estimate our model. In the *second* scenario, we use the growth rate of non-EU applications during the year prior to Brexit, that is, between 2015 and 2016, and apply it to compute the level and growth rate of applications from non-EU applications post-Brexit. Columns (2) and (3) in Table 3 display the results of this exercise. As shown therein, EU student applications would have fallen by 19 per cent in the first scenario, and by 15 per cent in the second scenario following Brexit. These estimates more than double the estimated impact from our preferred model specification in Table 2, Column (2), suggesting the latter represents a lower-bound estimate of the true impact of the referendum on international student applications from the EU. In other words, if non-EU international students were applying in greater numbers after the referendum in response to Brexit, the actual difference-in-differences estimate would have been much larger than the one measured in Table 2.

Table 3. Identification check—counterfactual scenarios.

Column:	(1)	(2)	(3)
Model Specification:	**Reference**	**Scenario #1**	**Scenario #2**
EU×Brexit	−0.071***	−0.188***	−0.152***
	(0.025)	(0.025)	(0.026)
DV Mean	0.033	0.070	0.064
Clusters	131	131	131
Observations	501,655	501,655	501,655

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. The following are the two scenarios being considered for imputing the post-Brexit growth rate for non-EU countries: (1) Scenario 1: apply to the outcome in levels the average yearly growth rate computed from before the referendum (2013–16) to impute the new level outcome for post-Brexit years and recompute the growth rate. (2) Scenario 2: apply to the outcome in levels the growth rate computed from 2015 to 2016 to impute the new level outcome and recompute the growth rate. Significance levels are given by: * $P < .10$, ** $P < .05$, *** $P < .01$.
Sources: (1) UCAS and (2) data on the size of the population of age 15–19 years from the World Bank Database (https://databank.worldbank.org/source/world-development-indicators).

6.2.2 Robustness checks

After confirming that our estimates are not overstated due to violations of the SUTVA, nor contaminated by differential pre-trends in international student applications, we conduct a series of robustness checks to further assess the reliability of our findings. We begin by experimenting with the inclusion of additional two- and three-way fixed effects. The results from this exercise are displayed in Table 4. Column (1) shows 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 country, subject, or university levels, as in columns (2), (3), and (4) of Table 4, 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 (8) 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 (5) and (6), respectively, as well as the inclusion of three-way subject–university–country fixed effects in column (7). 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.

Next, in Table 5, we experiment with adding additional time-varying controls. In column (2), we display the results after adding the unemployment rate in the country of origin—potentially a push factor. As shown therein, the estimated impact remains rather robust, suggesting Brexit lowered applications of foreign-born EU students by 6 per cent vis-à-vis applications from international students from outside the EU. Subsequently, given the prevalence of Chinese students among foreign-born applicants and the role that fluctuations in the Chinese yuan exchange rate against the British pound can play in shaping those flows (Machin and Murphy 2017), we experiment with adding the Chinese yuan–British pound exchange rate interacted with a dummy for China to our model. As shown in column (3), the estimated impact of Brexit proves rather stable.

In Table 6, we assess the sensitivity of our estimates to alterations of the estimation sample. As before, column (1) in Table 6 shows our preferred estimates from Table 2, column (3), to serve as reference. In column (2), we estimate our preferred specification using the larger dataset reported in Table 1 (2008–19). While the effect reasonably drops as we extend the pre-Brexit period from three to 8 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 per cent 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. The estimated impact of Brexit is somewhat higher, resulting in a 9 per cent reduction in the growth rate of applications. In

Table 4. Robustness checks #1—adding two- and three-way fixed effects.

Column:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Model specification:	Reference	Country–year	Subject–year	University–year	University–subject	University–country	Subject–university–country	Subject–university–year
EU×Brexit	−0.071***	−0.068***	−0.071***	−0.072***	−0.071***	−0.066**	−0.066**	−0.075***
	(0.025)	(0.000)	(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	0.033
Clusters	131	131	131	131	131	131	131	131
Observations	501,655	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: * $P < .10$, ** $P < .05$, *** $P < .01$.
Sources: (1) UCAS and (2) data on the size of the population of age 15–19 years from the World Bank Database (https://databank.worldbank.org/source/world-development-indicators).

Table 5. Robustness checks #2—additional controls.

Column:	(1)	(2)	(3)
Model specification:	Reference	Adding unemployment rate at origin	Adding Chinese yuan/BP exchange rate
EU×Brexit	−0.081***	−0.061**	−0.058**
	(0.019)	(0.028)	(0.027)
DV Mean	0.033	0.032	0.033
Clusters	169	89	131
Observations	501,655	413,205	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. 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: * $P < .10$, ** $P < .05$, *** $P < .01$.
Sources: (1) UCAS and (2) data on the size of the population of age 15–19 years from the World Bank Database (https://databank.worldbank.org/source/world-development-indicators); (3) Data country-level unemployment rates are obtained from the International Monetary Fund, World Economic Outlook Database, October 2020, available at: https://www.imf.org/external/datamapper/LUR@WEO/OEMDC/ADVEC/WEOWORLD (last accessed on 20 December 2022); (4) Data on the Chinese yuan-British pound exchange rate are from the Bank of England database, available at: https://www.bankofengland.co.uk/boeapps/database/ (last accessed on 6 July 2023).

Table 6. Robustness checks #3—using alternative samples.

Column:	(1)	(2)	(3)	(4)	(5)	(6)
Model specification:	Reference	2008–19	Excluding 2013	Excluding London	Excluding China	Excluding Top 5 countries
EU×Brexit	−0.071***	−0.055**	−0.090***	−0.074***	−0.071***	−0.093***
	(0.025)	(0.028)	(0.025)	(0.027)	(0.025)	(0.023)
DV Mean	0.033	0.034	0.028	0.034	0.033	0.032
Clusters	131	131	131	130	130	126
Observations	501,655	832,917	430,378	381,181	501,214	451664

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: * $P < .10$, ** $P < .05$, *** $P < .01$.
Sources: (1) UCAS and (2) data on the size of the population of age 15–19 years from the World Bank Database (https://databank.worldbank.org/source/world-development-indicators).

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 by 7 per cent. 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 five senders of international students to UK universities. Based on the estimates in column (6), Brexit lowers the growth rate of EU applications by 9 per cent, ruling out that our findings are driven by simultaneous changes happening in large sending countries.

Next, in Table 7, we experiment with aggregating our data at higher levels to address concerns regarding the possibility that some cells with few students and large annual percentage changes may be driving our results. To that end, we experiment with aggregating the data at the country–year level, as well as at the EU versus non-EU level using a wild cluster bootstrap for inference. As shown in columns (2) and (3), the results prove robust to the aggregation, with point estimates that are remarkably similar to those in our main model specification (column (1)), with Brexit lowering the growth rate of EU applications by nine and 10 per cent, respectively.

Finally, in Table 8, we experiment with estimating our main difference-in-differences specification using propensity score matching weights. Each observation is weighted (or excluded if the corresponding weight is equal to zero) by the frequency with which the observation is used as a match. Propensity score regressions are estimated using only the first year 2013 of our data and different vectors of regressors. The goal of this exercise is to assign different weights to each control unit depending on the probability to be treated based on predictors measured prior to Brexit. In columns (1), (4), and (7), the baseline predictors include total applications at the university–subject–country–year level, the share of STEM applications at the university level, and the size of the population 15–19 years of age at the country–year level. Columns (2), (5), and (8) further add information on whether the university is in Scotland, England, Northern Ireland, or Wales. Finally, the specifications in columns (3), (6), and (9) further control for country-of-origin GDP. As shown therein, the results prove robust to the use of various baseline predictors in the matching, as well as to the number of neighbors and caliper levels, with point estimates slightly changing and results remaining highly significant.

6.2.3 Placebo checks

To conclude, we conduct a couple of placebo checks aimed at confirming that our results are not driven by spurious correlations with potentially unobserved factors. *First*, we replace the treatment group with a placebo group constructed by randomly drawing twenty-seven countries from the pool of non-EU countries each time. Figure 3 shows the distribution of the difference-in-differences estimates

Table 7. Robustness checks #4—aggregating the data at higher levels.

Column:	**(1)**	**(2)**	**(3)**
Model specification:	**Reference**	**Country by year**	**EU/Non-EU by year**
EU×Brexit	−0.071***	−0.090***	−0.101
	(0.025)	(0.032)	–
P-value (Wild Cluster Bootstrap)			0.207
Clusters	131	131	2
Observations	501,655	917	14

Notes: The dependent variable is the growth rate in applications across two consecutive years by source country, subject, and university in column (1), by source country–year in column (2), and by EU versus non-EU group–year in column (3). 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 in column (1) include an EU dummy, subject, university, the population 15–19 years old in the source country by year, and year fixed effects; additional regressors in column (2) include an EU dummy, the population 15–19 years old in the source country by year, and year fixed effects; additional regressors in column (2) include an EU dummy, and year fixed effects. In column (1), each cell is weighted by the number of applications by country in the initial year. Standard errors in columns (1) and (2) in parentheses are clustered at country level. Significance levels are given by: * $P < .10$, ** $P < .05$, *** $P < .01$.
Sources: (1) UCAS and (2) data on the size of the population of age 15–19 years from the World Bank Database (https://databank.worldbank.org/source/world-development-indicators).

Table 8. Robustness checks #5—propensity score DiD.

Model specification:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Panel A: Nearest-neighbor with caliper equal to 0.5									
EU×Brexit	−0.056**	−0.070**	−0.079***	−0.077***	−0.069***	−0.071***	−0.081***	−0.064**	−0.065***
	(0.026)	(0.031)	(0.024)	(0.027)	(0.025)	(0.023)	(0.027)	(0.025)	(0.022)
DV Mean	0.028	0.028	0.032	0.027	0.027	0.031	0.027	0.027	0.030
SD	1.183	1.185	1.185	1.185	1.187	1.189	1.187	1.188	1.190
Clusters	130	145	140	131	149	142	133	149	143
Observations	267,722	282,849	271,089	283,262	303,338	291,403	291,186	313,075	301,168
Nearest Neighbors	5	5	5	8	8	8	10	10	10
Panel B: Nearest-neighbor with caliper equal to 0.1									
EU×Brexit	−0.056**	−0.070**	−0.079***	−0.077***	−0.069***	−0.071***	−0.081***	−0.064**	−0.065***
	(0.026)	(0.031)	(0.024)	(0.027)	(0.025)	(0.023)	(0.027)	(0.025)	(0.022)
DV Mean	0.028	0.028	0.032	0.027	0.027	0.031	0.027	0.027	0.030
SD	1.183	1.185	1.185	1.185	1.187	1.189	1.187	1.188	1.190
Clusters	130	145	140	131	149	142	133	149	143
Observations	267,722	282,849	271,089	283,262	303,338	291,403	291,186	313,075	301,168
Nearest neighbors	5	5	5	8	8	8	10	10	10

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. Each entry shows the point estimate from estimating regression (1), and each regression is weighted with the weight obtained from propensity score regressions using nearest neighbor with caliper and common support. Propensity score regressions only use data from the first year of our sample period—namely, from 2013. The vector of regressors used to estimate the propensity score differs across columns. Columns (1), (4), and (7) include total applications at university–subject–country–year level, the share of STEM applications at the university level, and population size 15–19 at country–year level as controls. Columns (2), (5), and (8) further add information on whether the university is in Scotland, England, Northern Ireland, or Wales. Finally, the specifications in columns (3), (6), and (9) add data on the country-of-origin GDP to specifications 2, 5, and 8. Robust standard errors clustered at country level are shown in parentheses. Significance levels are given by: * $P < .10$, ** $P < .05$, *** $P < .01$.
Sources: (1) UCAS and (2) data on the size of the population of age 15–19 years from the World Bank Database (https://databank.worldbank.org/source/world-development-indicators).

resulting from such an exercise using 500 placebo replications, as well as the actual point estimate obtained from column (2) in Table 2.[33] We expect the actual estimate to fall in the far-left tail of the distribution of placebo estimates, as confirmed by Fig. 3. The placebo point estimates are centered around zero and fall within a 95 per cent 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 per cent confidence interval band, suggesting that the estimated impact in Table 2 is not the byproduct of spurious correlations.

The *second* placebo exercise alters the timing of Brexit. Specifically, we experiment with specifying Brexit as taking place in 2014 and, subsequently, in 2015. Results are reported in Table 9 (columns (2) and (3)), which also reports the reference specification (column (1)) for convenience. None of these placebo regressions provide similar results to the specification using the actual timing of Brexit. Point estimates are much smaller and not statistically different from zero.

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 heterogeneous effect across universities, based on their selectivity, and across subject areas. Columns (1) and (2) of Panel A in Table 10 assess if that appears to have been the case, distinguishing between applications to more versus less selected universities—as specified in Table 10. Brexit appears to have lowered the growth rate of EU applications to selective universities by 7.5 per cent and by close to 7 per cent 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 were impacted by Brexit in a similar way at selective and non-selective institutions. This could

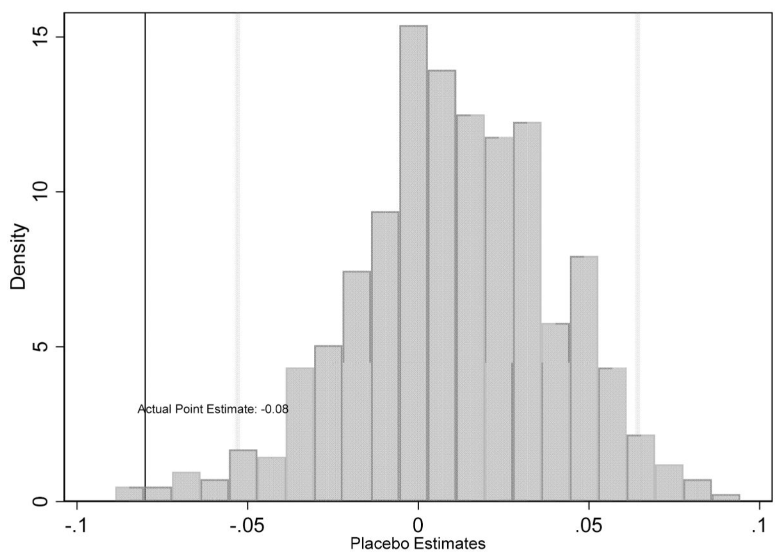

Figure 3. Robustness check: histogram of placebo estimates.

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 gray lines refer to the 95 per cent confidence interval.

Sources: (1) UCAS and (2) data on the size of the population of age 15–19 years from the World Bank Database (https://databank.worldbank.org/source/world-development-indicators).

[33] 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.

Table 9. Placebo in Brexit timing.

Column:	(1)	(2)	(3)
Model specification:	**Reference**	**Placebo Brexit 2014**	**Placebo Brexit 2015**
EU×Brexit	−0.071***	0.012	−0.020
	(0.025)	(0.037)	(0.038)
DV Mean	0.033	0.033	0.033
Clusters	131	131	131
Observations	501,655	501,655	501,655
Population 15–19 in source country by year	Yes	Yes	Yes
Weights	Yes	Yes	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: * $P < .10$, ** $P < .05$, *** $P < .01$.
Sources: (1) UCAS and (2) data on the size of the population of age 15–19 years from the World Bank Database (https://databank.worldbank.org/source/world-development-indicators).

Table 10. Heterogeneous effects.

Panel A: By University Selectiveness and Subject Area				
Column:	(1)	(2)	(3)	(4)
Group:	**Selective**	**Non-selective**	**STEM**	**Non-STEM**
EU×Brexit	−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 EU×Brexit	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**
EU×Brexit	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. Selective universities are defined according to the Russell Group, which includes twenty-four 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. 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: * $P < .10$, ** $P < .05$, *** $P < .01$.
Sources: (1) UCAS and (2) data on the size of the population of age 15–19 years from the World Bank Database (https://databank.worldbank.org/source/world-development-indicators).

be the case if institutions foreseeing a significant drop in applications after Brexit offered financial incentives to applicants.[34]

[34] We also examined a more restrictive definition of selective universities by considering, among the Russell Group Universities, the top ten UK Universities according to the Times Higher Education University Ranking 2015: University of

Next, we look at whether the impact of Brexit 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.[35] 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 10, Panel A, tests if that was the case. Based on the estimates therein, Brexit had a larger impact on the growth rate of EU applications in STEM (10 per cent reduction) when compared to non-STEM (5 per cent drop).[36] 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 10, applications to life sciences,[37] engineering, computer science, and medicine dropped between 13 and 15 per cent following Brexit, bearing the brunt of the referendum's vote outcome. The larger drop experienced by these fields might be related to the already much higher cost associated to studying these disciplines due to the use of labs and other facilities, as well as their high demand.

In sum, Brexit resulted in a reduced volume of international student applications across all institutions of higher education—selective and less selective. In addition, it 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, b; 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, Mobarak, and Maskus 2012) and in the UK (Migration Advisory Committee 2018).

8. Mechanisms and enrolment implications

As discussed in the Introduction, Brexit may have altered international student applications from the EU through a myriad of channels, including the prospect of a fee increase, the end of the ability to stay long-term in the UK post-graduation, and potentially psychological costs. In this section, we address some of those mechanisms to, subsequently, assess if the observed reduction in applications ultimately translated into lower international enrolments.

To start, we distinguish between two sets of likely determinants of changes in the volume of international student applications from the EU 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 UK might be after completing their studies. Both sets of factors have been shown to play a key role 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 USA, 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. In a similar vein, Bhagwati and Rao (1999), Chiswick (1999), and Rosenzweig, Irwin, and Williamson (2006), among others, emphasize how

Cambridge, University of Oxford, University College London, Imperial College of Science, Technology, and Medicine, University of Manchester, University of Edinburgh, King's College London, and University of Bristol. Results are consistent with the less restrictive definition (available upon request).

35 For example, in the USA, the Department of Homeland Security favored 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, b; Kantor and Whalley 2014; Peri, Shih, and Sparber 2015).

36 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.

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

international student applications are often tied to the prospect of securing employment in the destination country.

To gage the potential role played by psychological factors, we first 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. London is included in the remain group. 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 11, Brexit 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.

Because testing for the relevance of psychological factors without specific survey data on the topic is challenging, we also experiment with estimating our main model for each EU country at a time. If concerns about anti-immigrant sentiments in UK regions that voted to leave the EU were the main driver of the observed changes in students' applications from the EU, we would not expect to see much heterogeneity in the response of EU students to the referendum. Figure 4 displays the distribution of the estimated impacts of Brexit on the volume of international students from the various EU country members, vis-à-vis other non-EU international students. The dark line indicates the estimate in our preferred model specification, that is, column (2) in Table 2. As shown therein, there is significant variation in the estimates, with the vast majority being negative and statistically different from zero. Only four of the twenty-seven EU country members—namely, Denmark, Latvia, Lithuania, and Portugal, had positive estimates, and only three where statistically different from zero at conventional levels. Heterogeneity in the response to Brexit hints on factors, other than anti-immigrant sentiments in specific UK regions, as key drivers of the observed reduction in applications from EU students.

Subsequently, we consider the role of economic factors—namely, changes in students' ability to stay long-term in the UK after completing their studies. Once more, there are limitations to working with administrative data lacking detail on the specific financial situation of applicants and/or their employment prospects. Hence, we turn to 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. If a key determinant of EU student applications to UK universities is their ability to live and work in the UK 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 UK 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 11 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. 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. Both median and percentile values are computed separately for EU and non-EU countries. 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 versus above the median in that year, as well as between students from countries in the top 75th versus the bottom 25th percentile of the employment to population ratio distributions.

Brexit appears to have significantly lowered applications among students originating from countries with lower GDP per capita—by 11 per cent for those from countries with rates below the median (column (2), Panel B) and by 20 per cent for their counterparts from countries with rates below the 25th percentile (column (4), Panel B). Similarly, applications from EU countries dropped by 14 per cent (column (2), Panel C) and 17 per cent (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 (9 per cent) among their counterparts from countries with employment-to-population ratios above the median or the 75th percentile, correspondingly. Overall, the differential impact of Brexit on applications based on the source's country labor market

Table 11. Mechanisms.

Perception of Anti-EU Sentiments at Destination				
Column:	**(1)**		**(2)**	
Panel A: By UK Region	**Leave**		**Remain**	
EU×Brexit	−0.074***		−0.066**	
	(0.024)		(0.031)	
DV Mean	0.036		0.027	
Clusters	130		131	
Observations	316,069		185,586	
P-value EU×Brexit		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**
EU×Brexit	−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 EU×Brexit	0.183		0.001	
Panel C: By Emp Rate (16+) at Origin	**Above median**	**Below median**	**>75 Pct**	**<25 Pct**
EU×Brexit	−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 EU×Brexit	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: * $P < .10$, ** $P < .05$, *** $P < .01$.

Sources: (1) UCAS and (2) data on the size of the population of age 15–19 years from the World Bank Database (https://databank.worldbank.org/source/world-development-indicators); (3) Employment rate and GDP per capita (ppp at constant 2017 prices) are from the World Bank—World Development Indicators Database, available at: https://databank.worldbank.org/source/world-development-indicators/ (last accessed on 20 December 2022).

and economic prospects points to the potential relevance of curtailed opportunities to live and work in the UK 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 as proxied by acceptances in the UCAS data. 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 12 displays the results from this exercise.

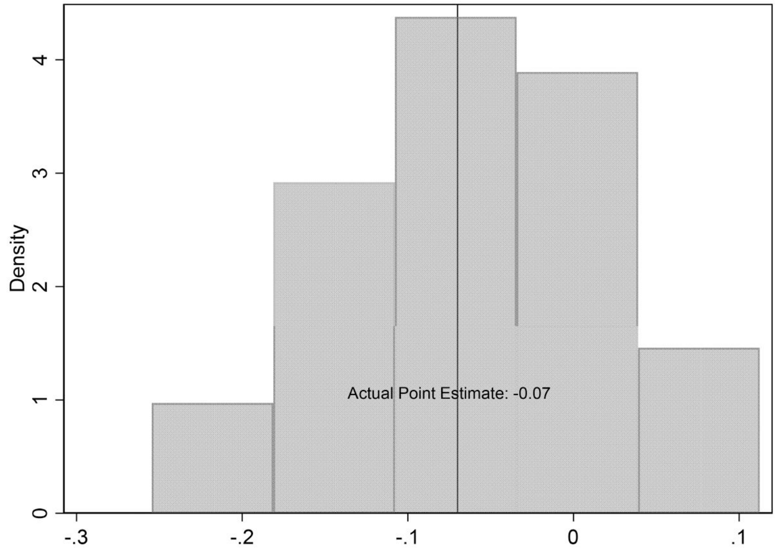

Figure 4. Histogram of results by EU country.

Notes: This figure shows the distribution of the coefficients obtained from separate regressions run for one EU country at a time using our baseline specification (Table 2, column (2)). The dark vertical line refers to the actual point estimate reported in Column (2) of Table 2. Only four of the twenty-seven EU countries (i.e. Denmark, Latvia, Lithuania, and Portugal) reported positive point estimates, and only three were statistically different from zero at conventional significance levels.

Sources: (1) UCAS and (2) data on the size of the population of age 15–19 years from the World Bank Database (https://databank.worldbank.org/source/world-development-indicators).

Table 12. Enrolment implications conditional on applying.

Column:	(1)	(2)	(3)
EU×Brexit	−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: * $P < .10$, ** $P < .05$, *** $P < .01$.
Sources: (1) UCAS and (2) data on the size of the population of age 15–19 years from the World Bank Database (https://databank.worldbank.org/source/world-development-indicators).

As with applications, results are rather consistent across the three model specifications. Focusing on our preferred model in column (3), we document a 5 per cent reduction in international student enrolments from the EU, vis-à-vis other origins, after Brexit.[38] As such, Brexit appears to have lowered international student applications enough to curtail enrolments. The smaller effect on enrolment when compared to the impact on applications (5 per cent versus 7 per cent reduction) hints on universities potentially raising admission rates because of reduced applications if students were not more likely to accept a university offer. Either way, EU enrolments appear to have also dropped with Brexit.[39]

[38] Column (2) of Table A2 in the Appendix reports similar impacts if we use a log-level specification.
[39] As a robustness check, we repeat the analysis in Table 6 using HESA (2020) 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

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 7 per cent when compared to the growth rate of international applications originating from non-EU members. This effect, which appears robust to several robustness and identification checks, has affected applications similarly in both selective and 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.

We also explore alternative mechanisms at play in our sample. First, we consider the possibility of EU students' perception of increased discrimination toward EU nationals in UK regions that voted to leave the EU—a factor that appears to have shaped migrants' return intentions (i.e. Falkingham et al. 2021). Yet, we find similar impacts of Brexit across UK regions, suggesting that these factors are not playing a decisive role or that students were, themselves, unaware of how the various regions voted in the referendum. Furthermore, the heterogeneous responses to Brexit across the various EU country members suggest that concerns regarding anti-immigrant sentiments in specific UK regions were not likely to be a main driver. Second, we explore the role of economic factors, such as the increased uncertainty regarding the ability to stay and work in the country after graduation in shaping students' incentive to apply as suggested by prior work examining the determinants of student mobility and matriculation (e.g. Bhagwati and Rao 1999; Chiswick 1999; Dustmann, Fadlon, and Weiss 2011). 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 UK upon completion of their studies might have been an important pull factor. These findings point to deteriorating of such prospects as a likely driver behind EU students' application responsiveness.

To conclude, 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, restricted labor mobility and employment prospects after graduation might have curtailed applications from EU students for whom the ability to live and work in the UK after completing their studies might have been an important pull factor to study in the UK. The documented impacts 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 particularly impacting 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, and the UK's ranking as the second most frequent destination for international students—36 per cent of whom originate from EU country members (HESA 2020), understanding the impact of policy changes affecting migration, as was the case with Brexit, is well-warranted.

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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; therefore, 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 include 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 A5 in the Appendix) generally corroborate our findings, with EU enrolments rates dropping anywhere between four and 6 per cent, when compared to those from non-EU students, after Brexit. Note that the enrolment analysis based on UCAS data considers enrolment *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 enrolment data can be matched.

Arnaud Chevalier, Melanie Lührmann, Giovanni Peri, and participants at the American Society of Hispanic Economists, the Association for Public Policy Analysis & Management, the Eastern Economic Association meetings, Iowa State University, the Royal Economic Society, Royal Holloway—University of London, the Scotland and Northern England Applied Microeconomics Workshop, the Scottish Economic Society conference, the Society of Labor Economists meetings, the Southern Economic Association meetings, and University of Strathclyde. For the purpose of open access, Agnese Romiti has applied a Creative Commons Attribution (CC BY) license to any Author Accepted Manuscript version arising from this submission.

Conflict of interest statement. None declared.

Appendix

Table A1. Total applications by British versus 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 2019–16	38,110	−216,315
% Change 2019–16	0.081	−0.092

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

Table A2. The impact of Brexit on EU applications and enrolments.

Column:	(1)	(2)
Dependent variable:	**Log (Applications)**	**Log (Enrolments)**
EU × Brexit	−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 and enrolments 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. Estimates are unweighted and standard errors in parentheses are clustered at the country level. Significance levels are given by: * $P<.10$, ** $P<.05$, *** $P<.01$.
Sources: (1) UCAS and (2) data on the size of the population of age 15–19 years from the World Bank Database (https://databank.worldbank.org/source/world-development-indicators).

Table A3. Effect of 2012 tuition fee rise.

Column:	(1)	(2)
Sample:	**2008–19**	**2008–16**
EU × Fee2012	−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. The variable 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: * $P < .10$, ** $P < .05$, *** $P < .01$.
Sources: (1) UCAS and (2) data on the size of the population of age 15–19 years from the World Bank Database (https://databank.worldbank.org/source/world-development-indicators).

Table A4. Treatment-by-year analysis of Brexit on EU applications.

EU × 2013	−0.116*
	(0.070)
EU × 2014	−0.076
	(0.061)
EU×2015	−0.035
	(0.058)
EU×2017	−0.129**
	(0.057)
EU×2018	−0.149***
	(0.044)
EU×2019	−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 EU×Year 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: * $P < .10$, ** $P < .05$, *** $P < .01$.
Sources: (1) UCAS and (2) data on the size of the population of age 15–19 years from the World Bank Database (https://databank.worldbank.org/source/world-development-indicators).

Table A5. The impact of Brexit on EU enrolments using HESA data.

Column:	(1)	(2)	(3)
EU × Brexit	−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 total enrolment by country in the initial year. Standard errors in parentheses are clustered at country level. Significance levels are given by: * $P < .10$, ** $P < .05$, *** $P < .01$.
Sources: (1) HESA and (2) data on the size of the population of age 15–19 years from the World Bank Database (https://databank.worldbank.org/source/world-development-indicators).

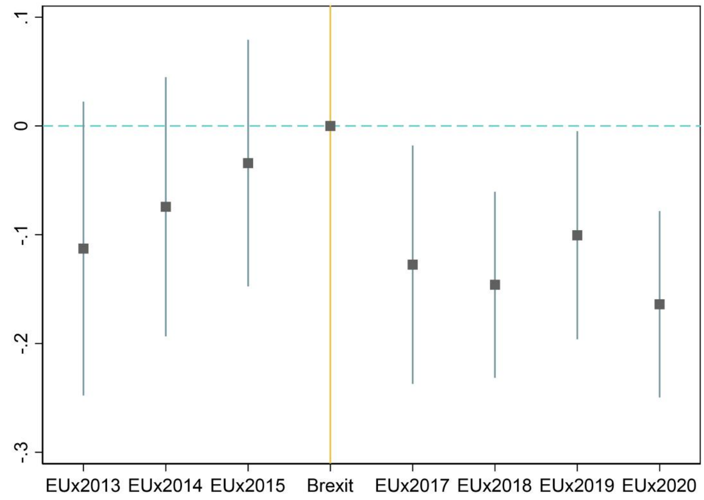

Figure A1. Treatment-by-year plot (2013–20)

Notes: The figure shows the coefficients of the interaction of leads and lags of the variable EU×Year, 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 Equation (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 per cent confidence intervals obtained using clustered standard errors at country level.

Sources: (1) UCAS and (2) data on the size of the population of age 15–19 years from the World Bank Database (https://databank.worldbank.org/source/world-development-indicators).

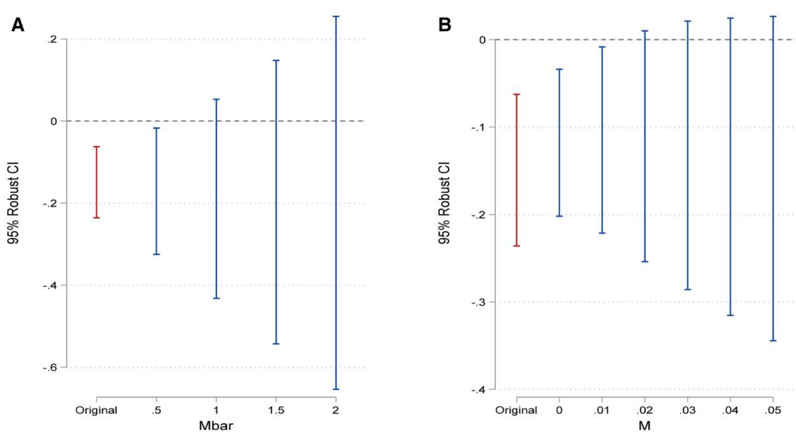

Figure A2. Parallel trends sensitivity analysis—Rambachan and Roth (2023) test. (A) Bounds on relative magnitude. (B) Smoothness restriction.

Notes: The figure shows the “breakdown” parameter values of the Mbar (Panel A), and M (Panel B) parameters corresponding to the treatment effect for the first post-treatment year (2017).

Sources: (1) UCAS and (2) data on the size of the population of age 15–19 years from the World Bank Database (https://databank.worldbank.org/source/world-development-indicators).

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