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IZA DP No. 14247

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ABSTRACT

International Student Applications in the United Kingdom after Brexit*

On June 23, 2016, the people of the United Kingdom voted to leave the European Union. We examine how this decision (henceforth, Brexit) has impacted international student applications in the United Kingdom. Using administrative data spanning from 2013 through 2019, along with a quasi-experimental approach, we find evidence of Brexit curtailing the growth rate of international student applications by 14 percent. The impact appears larger for applications to pursue STEM studies and for those received by more selective universities, suggestive of students with more alternatives choosing to study elsewhere. Furthermore, applications appear to have dropped the most among EU students originating from countries with weaker labor markets and economies for whom the ability to stay in the United Kingdom after their studies might have been a critical pull factor. Finally, the drop in applications has resulted into fewer international enrolments. Given the contributions of international student exchanges to research, development and growth, further research on the implications of Brexit for UK universities and the ability to attract valuable talent is well-warranted.

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

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

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

1. Introduction

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

Britain's split from the EU changes its relationship to the bloc on trade, security and, importantly, migration. Brexit affects the cost of studying in the United Kingdom by modifying students' ability to secure loans and visa requirements, despite any potential savings from a devalued British pound. Crucially, Brexit increases uncertainty regarding international students' ability to stay in the country and seek employment after completion of their studies. This higher implicit economic cost could deter

prospective students from considering studying in the United Kingdom in the first place. Finally, aside from any economic costs, Brexit could also deter prospective students from attending a country they feel is no longer welcoming migrants (Falkingham *et al*., forthcoming). We assess how a unique institutional change, such as the UK's decision to withdraw from the EU, has affected international student applications in the country. The outcome of the referendum on Brexit, where England (but not London) and Wales voted in favor to exit the bloc, whereas Scotland and Northern Ireland voted otherwise,[1] was unexpected.[2] 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 in a UK university.

Figure 1 shows international student applications to UK universities from the EU and non-EU block from 2007 through 2019. While both exhibit a somewhat parallel upward trend from 2007 through 2016, international student applications from EU countries stagnated after 2016 whereas applications from non-EU countries rose by 14 percent. Using administrative data from the Universities and Colleges Admissions Service (UCAS) and a difference-in-difference approach,[3] we compare changes in

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

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

[3] 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 is not included in UCAS figures –they mostly consist of full-time higher education students in further education colleges.

international student applications from EU member countries within source country, university, and subject of study to those from non-EU members, pre- vs post-UK's vote to leave the EU. International students from EU member countries constitute the *treatment* group, whereas international students from elsewhere make up the primary *control* group.[4] The control group serves the purpose of netting out other changes taking place over the same period potentially affecting undergraduate applications of prospective international EU and non-EU students in alike ways.

We find that Brexit has significantly lowered applications originating from EU country members. Specifically, when compared to international student applications originating from elsewhere in the world, the growth rate of EU applications dropped by 14 percent following the Brexit referendum. This effect, which proves robust to the use of other model specifications, a different control group including UK natives, an alternative dependent variable specification, and various study samples, is not observed when we use randomized samples of non-EU countries as treatment groups in a placebo exercise. Additionally, we rule out anticipation effects as changes in the volume of international student applications from the EU did not precede the Brexit referendum; instead, they occurred right after, persisting during the 3-year period that followed. Importantly, the effect of Brexit varies by subject of study and selectivity of the academic

These are colleges offering courses for people over the age of sixteen that involve school-level qualifications or university entrance qualifications, as well as educational courses integrating school or university curriculum with the workplace.

[4] Given our focus on international student applications, applications from the UK are excluded. However, as a robustness check, we also consider UK applicants as part of the control group.

institution –in all instances hinting at positive selected prospective students choosing to apply elsewhere.

We further investigate some of the likely mechanisms at play by focusing on the role played by two key factors in explaining student applications: (1) *psychological factors* as captured by a potentially unfriendly environment towards EU residents after Brexit, and/or (2) *economic factors* related to the now curtailed ability to stay long term in the United Kingdom upon completion of their studies to find employment. To assess the relevance of psychological costs in shaping student applications, we explore if Brexit had a differential impact across UK regions depending on whether they voted to remain or to leave the EU. We find that the effect is homogeneous across all UK regions regardless of how they voted for Brexit, suggesting that concerns about the emergence of xenophobic sentiments, which could vary across regions depending on how they voted, might not have been the primary driver. Next, we explore how the curtailed ability to stay long term in the United Kingdom after completing their studies and find employment might have influenced international student applications. To that end, we examine how applications vary based on economic conditions in the home countries of prospective students, as captured by their GDP per capita and unemployment rate. We find evidence of international applications declining to a larger extent after Brexit among EU students from countries with lower per capita GDP and higher unemployment rate –supposedly students who would have been more interested in staying in the United Kingdom after completion of their studies to live and work. The results are suggestive

of students' newly restricted employment prospects playing a critical role in explaining the decline in international applications after Brexit.

To conclude, we explore if the observed reductions in student applications had any implications for international student enrolments. After all, enrolments could remain unchanged if applications far exceeded admissions or if universities reacted by raising admission rates 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.

Understanding the diverse implications of Brexit is critical. In addition to potential trade and investment disruptions accompanying the undoing of 46 years of economic integration, Brexit will end the free movement of people, affecting the right of people from elsewhere in EU to move to Britain and vice versa. This has created anxiety on the part of UK universities, which have increasingly relied on international applications. International students generate several positive financial and creativity spillovers for receiving economies. They foster innovation (Hunt and Gauthier-Loiselle, 2010; and Stuen *et al.*, 2012) and, for local economies and public universities increasingly facing funding cuts, they can represent an important source of revenue (Bound *et al.*, 2020).

In addition to financial and innovation considerations, demographic trends make this question particularly relevant considering the shrinking 18-years-old British population since 2017 (UCAS, 2017) –a trend potentially responsible for the recent decline in enrolments of UK students in undergraduate programs. General ageing of the

UK population (ONS, 2017) makes attracting and retaining international students an important factor to sustain an aging society.

In sum, understanding the factors driving international student applications is key in ensuring student inflows and their positive externalities. This is especially relevant for a country such as the United Kingdom, which is second only to the United States in hosting international students (OECD, 2013) and where 14 percent of undergraduate students and 34 percent of postgraduate students are foreign-born (HESA, 2019). Yet, to this date, we have no understanding of what the impact of Brexit will be on UK universities' ability to attract foreign talent.

This study contributes to the understanding of the implications of Brexit. Recent literature on Brexit has examined the determinants of the Brexit vote. Areas with low educational attainment and incomes, high unemployment, and a historically large concentration of employment in manufacturing were more likely to vote for Brexit (Becker *et al*., 2017). At the individual level, one of the main drivers were feelings about income rather than actual income (Liberini *et al.*, 2019). Other studies have explored how Brexit impacted macroeconomic outcomes (*e.g.* Born *et al*., 2019; Breinlich *et al*., 2020), as well as public safety (*e.g.* Carr *et al.*, 2020). Less has been done in terms of Brexit impacts on academics. We address that gap by assessing how Brexit has impacted the volume, as well as the potential selectivity, of international applications.

More generally, the analysis contributes to a growing academic literature examining the determinants of student mobility and applications. This literature underscores the relevance of employment and earnings' aspirations in shaping

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

From a policy perspective, understanding the implications of Brexit on international student applications may prove crucial to safeguard universities from the loss of revenues as applications from within the United Kingdom have been declining. But, most importantly, it is vital in attracting international talent for innovation and growth.

2. Institutional Background

Prior to Brexit, international students from other EU country members enjoyed 'home fee status' in the United Kingdom. This meant they paid the same fees as students from the area of the United Kingdom where they were pursuing their studies (*i.e.* England, Northern Ireland, Scotland, or Wales). In addition, they 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. Most importantly, they enjoyed the right to live and work in the United Kingdom upon completion of their studies.

Once Brexit is fully implemented –that is, after the transition period ending on December 31, 2020–conditions will change. EU students who arrived in the United Kingdom before January 1, 2021, will be able to maintain the above conditions by applying for the so-called EU Settlement Scheme. EU students arriving after January 1, 2021 and starting their studies prior to July 31, 2021, will experience changes in their immigration status, but will be able to maintain the 'home status fee' that their counterparts enjoyed prior to Brexit. Lastly, those arriving after January 1, 2021 and starting their studies after July 2021, will not only experience a change in their immigration status, but also no longer enjoy the 'home status fee' of their predecessors. Each UK university will set its own fees for EU students. In addition, students will need to apply for a student visa if they are planning to stay for a course lasting beyond 6 months. This will require paying an application fee (£348) and having a current passport. They will also need to pay an Immigration Health Surcharge (£470/year) that provides them with access to the UK National Health Service. Finally, unlike their predecessors, they might not be able to apply for a student loan in England, Northern Ireland or Wales, or have their fees paid by Student Awards Agency Scotland (SAAS) if

they are studying as an undergraduate in Scotland.[5] While these provisions are still to be implemented and, as such, do not apply to EU applicants included in this analysis, the expectation of changing conditions (such as the ability to live and work in the United Kingdom after completing their studies) might have impacted the decision to apply to the United Kingdom of many EU prospective students.

3. Conceptual Framework

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

As in Kato and Sparber (2013), who model the response of international student applications to a reduction in the H-1B quota in the United States, we assume that, when deciding whether to study in the United Kingdom, EU students will compare the expected benefit from doing so in terms of labor market prospects upon graduation (NB_i) to their reservation wage of studying elsewhere (RW_i) –both of which depend on students' skill levels (s_i). If the probability of finding employment and being able to stay

[5] For more information, please visit the British Council's site at https://study-uk.britishcouncil.org/moving-uk/eu-students.

long-term in the United Kingdom is given by p, where $0 < p < 1$, and we assume zero migration costs for simplicity, students will apply to study in the United Kingdom only if: $[p * NB(s_i)] > RW(s_i)$. Note that a lower p under Brexit lowers the propensity for expected net benefits to exceed their reservation wage and, therefore, the application likelihood of international students. Hence, our *primary hypothesis* is that Brexit might reduce the number of applications received from EU students.

A *secondary hypothesis* is that such impacts are likely to be heterogeneous, varying across universities and subject areas.[6] A priori, it remains ambiguous how the average quality of applicants might change. If positively selected applicants are more sensitive to policy changes than other applicants, either because they tend to be better informed, have more options to study elsewhere, or because they were already the sole ones finding employment in the United Kingdom upon graduation, we might expect a decline in the average quality of applicants. Nevertheless, if Brexit induces employers to seek employment visas only for positively selected graduates, these applicants might not be particularly hurt by the restrictions imposed by Brexit on their ability to stay long term in the United Kingdom upon graduation. Rather, the brunt of the policy will fall upon applicants on the left-tail of the ability distribution, who now will find it rather difficult to stick around upon completion of their degrees.

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

4. Data and Descriptive Statistics

We use administrative data from the Universities and Colleges Admissions Service (UCAS) on undergraduate applications to UK universities over the 2013 through 2019 period.[7] UCAS is the body that manages all applications to undergraduate courses in the United Kingdom. Scotland is an exception, as around a third of full-time undergraduate students is not included in UCAS figures. They are applicants to colleges providing school level or university entrance qualifications, 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.[8] For most courses in the United Kingdom, the deadline to apply is in January of the year when the course starts. For any course at the University of Cambridge and Oxford, and most courses in medicine, veterinary medicine/science, and dentistry, the deadline is in October of the year before the course starts.

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

[7] We check the robustness of our results to using a longer time series that starts in 2007 (see Column 4 in Table 3). However, we focus the analysis on the period 2013-2019 to exclude the effect of legislation increasing tuition fees for home and EU students introduced in 2012. Sá (2019) shows that the increase in tuition fees reduced substantially university applications by comparing applications to UK universities in regions subject to the increase in fees (*i.e.* England, Wales and Northern Ireland) to applications in regions that were not subject to the fee increase (*i.e.* Scotland). Focusing on the 2013-2019 also results in a balanced time window around the treatment year, 2016.

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

admissions, or if universities raise admission rates to counteract a decline in student applications. While we make use of enrolment data to assess the consequences of declining student applications on final student registrations,[9] 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.[10]

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. We create a balanced panel of 505,197 cells, consisting of 169 countries, 294 universities, 25 subjects, and 7 years, by setting empty cells equal to zero.[11] Table 1 provides a bird view of changes in international student applications.[12]

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

[9] According to the definition provided by UCAS, this variable refers to the number of applicants who have accepted an offer from a University.

[10] Our analysis is not affected by this rule change as our sample starts in 2008.

[11] To retain cells with a value of zero, we use the inverse hyperbolic sine transformation. As we discuss in Section 6 and show in Table 3B, results prove robust to dropping those cells.

[12] Each cell is weighted by the size of the population of age 15-19 in the first year (2008).

applying to UK universities after 2008 up until 2011, possibly in response to the unfolding Great Recession, which lowered the opportunity cost of pursuing a 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.[13] *Second*, applications of EU students dropped substantially in 2012 following the large increase in tuition fees from an average of £3,375 to approximately £9,000 per year, which affected all UK and EU students in all UK regions (except for Scotland) (Sá, 2019). *Third*, despite a reduction in applications from 2015 to 2016 among the comparison group (non-EU students), the largest decline in applications from EU students occurred between 2016 and 2017, coinciding with the referendum on Brexit. Given the differential impact of the 2012 tuition fee hike on applications of EU and non-EU students, we focus our attention on the period starting right after –namely, 2013-2019. This results in a balanced time window spanning from three years prior to three years after Brexit that, in addition, allows us to gauge the impacts of Brexit more precisely by narrowing the time window around treatment.

At the bottom of Table 1, we compute the difference in the growth rate of international applications between 2016 and the last year for which we have data (*i.e.* 2019) for students from an EU country member and for students from a non-EU country member. As shown therein, the rate of growth of international student applications from

[13] 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.

non-EU countries only slightly declined by 0.8 percentage points over that period, whereas it declined by 8.3 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 9.8 percentage points over the 2016 through 2019 period.

5. Methodology

While revealing, the figures in Table 1 are merely descriptive. Given the quasi-natural experimental feature of Brexit, we rely on a difference-in-difference approach to examine changes in the applications of international students from EU and non-EU countries, pre vs. post the referendum on Brexit as follows:[14]

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

where: $Y_{c,s,u,t}$ is the log difference or growth rate in international student applications from country (*c*), for subject of study (*s*), at university (*u*) from year (*t*-1) to year *t*. Working with growth rates enables us to address the fact that the volume of applications from any given country to an institution in a particular subject are likely to be correlated over time due to the existence of established programs and networking among students and institutions. The variable $Post_t$ is a dichotomous variable that equals one for the period after the Brexit referendum (from 2017 onward), and zero otherwise.[15] Similarly,

[14] Due to their similarities, we will first compare international students from EU countries (our treatment group) to international students from non-EU country members (our control group). However, we will also experiment with an alternative control group, including native students.

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

the TG_c variable is a dummy equal to one if the data refer to international students from a country belonging to the EU bloc, and zero otherwise.

We are particularly interested in the coefficient β_1, which captures how international student applications from EU countries changed, relative to those of non-EU countries, from before to after the Brexit referendum. Equation (1) also contains subject of study and university-specific fixed-effects to capture unobservable time-invariant traits possibly affecting the outcomes of interest (*e.g.* the popularity of a given university and/or area of study, as in the case of STEM fields in recent years), as well as year fixed effects to control for temporal variation in our outcome. In alternative model specifications, we experiment with including the size of the population aged 15 to 19 years old in each source country every year to account for changes in size of college-entry cohorts.[16] We estimate equation (1) by OLS and cluster standard errors at the country level to allow for within group correlation in standard errors (Bertrand *et al.*, 2004).

6. Brexit and International Applications to UK Universities

6.1 Main Findings

Table 2 reports the results from estimating three different specifications of equation (1). In column (1), we display the estimated impact from the benchmark

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

specification reported in equation (1). In column (2), we include the size of the potential student cohort (age 15-19) in the source country in any given year as an additional control.[17] Finally, in column (3), we take into the account the fact that growth rates might change more drastically when the initial volume of international students in a cell is relatively small vs. large. Therefore, we use the size of the population aged 15 to 19 in the source country at the beginning of our period of analysis 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 the one percent level in all three columns. Focusing on the most complete and preferred model specification (column 3), the Brexit referendum resulted in a 14 percent reduction in the growth of rate of applications from the EU, when compared to those from other international non-EU students.[18] To place our findings in context, the impact of Brexit would be equivalent to half the effect of the 2012 tuition fee increase on applications from British students (Sà, 2019).

6.2 Identification and Robustness Checks

We conduct a series of robustness checks to further assess the reliability of our findings to the inclusion of additional two- and three-way fixed effects, the use of an alternative control group, the specification of the dependent variable, the use of a larger dataset, or the exclusion of London from the analysis. These are displayed in Tables 3A

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

[18] This is equivalent to 12 percent of a standard deviation reduction in the dependent variable.

and 3B. Specifically, Table 3A shows the results from adding two- and three-way fixed effects. Column (1) displays our preferred estimates from Table 2, column (3), to serve as reference. Because our specification is the log difference of cells defined at the country-university-subject level between two consecutive years, the inclusion of two-way fixed-effects involving year-to-year variation at either the subject or the university, as in columns (2) and (3) of Table 3A, naturally makes no difference on the estimated impact of Brexit. Similarly, the inclusion of three-way fixed effects capturing the year-to-year variation at the university-subject level in column (6) leaves the estimated impact of Brexit unchanged. A bit more interesting is the inclusion of two-way university-subject and country-university fixed effects in columns (4) and (5), respectively, as well as the inclusion of three-way country-university-subject 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 combinations.[19]

To further assess if our results are driven by spurious correlations with unobserved factors, we also conduct a series of placebo estimations in which we replace the treatment group with alternative placebo groups obtained drawing random samples from non-EU country members. Figure 1 shows the distribution of the difference-in-difference estimates resulting from such an exercise using 500 placebo replications, as

[19] We also experimented with including multiple combinations of two- and three-way fixed effects, such as: subject-year plus university-year, as well as subject-university-year, subject-year, plus university-year fixed effects. Results remained virtually unchanged.

well as the actual point estimate obtained from column (3) in Table 2. Our expectation is that the actual estimate should fall in the far tail of the distribution of placebo estimates. This is confirmed by Figure 2. The placebo point estimates are distributed around zero and fall within a 95 percent confidence interval band around zero, suggesting they are not statistically different from zero. In contrast, the actual point estimate falls to the left and well outside the 95 percent confidence interval band, suggesting that the estimated impact in Table 2 is not the byproduct of spurious correlations.

Next, in Table 3B, we further assess the robustness of our findings to the specification of the dependent variable, control group, and estimation sample. As before, column (1) in Table 3B shows our preferred estimates from Table 2, column (3), to serve as reference. Next, in column (2), we display the results when the dependent variable is specified in log levels versus log differences. To address applications trends at the country of origin, university, and subject levels taken care of through the differenced analysis, we include country of origin, university, and subject of study time trends. Results remain remarkably consistent, with Brexit reducing applications from EU country members by 10.7 percent.[20]

Subsequently, in column (3), we experiment with altering the control group. In addition to non-EU applicants, we include UK natives in the control group. Natives are, admittedly, quite distinct from international students and, arguably, not as comparable.

[20] This specification excludes all cells with a zero value and is comparable to the one used by Sa' (2019) to estimate the effect of the tuition fee rise on university applications.

Doing so, however, does not significantly alter our results, which remain practically unchanged.

Finally, in columns (4) through (6), we experiment with changing our sample of study in various ways. *First*, we estimate our preferred specification using the larger dataset reported in Table 1 (2008-2019). As shown therein, while the effect reasonably drops as we extend the pre-Brexit period from three to eight years, we still observe a statistically significant and substantial reduction in the growth rate of international student applications from EU countries of approximately 12 percent post-Brexit. *Second*, we experiment with excluding London from our sample of study. As shown in column (5), the point estimates become only slightly higher than the baseline estimate, with Brexit reducing the growth rate of international applications from EU countries, when compared to international applications from elsewhere, by 15.9 percent. *Finally*, in column (6), we display the results when we exclude empty cells from the analysis –cells that were otherwise assigned a zero value. As shown therein, the results prove remarkably robust, with Brexit reducing the growth rate of EU applications by 10.5 percent, when compared to applications from other international students.

To conclude, we conduct an event-study type analysis to gauge the validity of the parallel trend assumption in applications from EU and international non-EU students prior to the Brexit referendum, as well as to gauge any dynamic effects of the referendum

on university applications. To that end, we explore trends in international student applications three years prior and three years after the Brexit referendum, as follows:[21]

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

Each coefficient $\beta_{3,t}$ should be interpreted with respect to the year 2016, the year when the referendum took place, which is the omitted interaction term.

As shown in Table 4, there is no evidence of a significant differential trend in applications from EU and non-EU countries prior to Brexit, suggesting that international students from non-EU countries are a suitable control group. In addition, these results rule out anticipation effects –consistent with the unexpected nature of the referendum results. Instead, what we observe is a significant 17 percent reduction in the growth rate of international student applications from the EU, relative to those coming from non-EU countries, after the Brexit referendum. This impact is also durable, remaining statistically significant and negative up to three years after Brexit.

Figure 3 displays the coefficients from the event-study type analysis reported in Table 4 graphically, along with their 95 percent confidence intervals. The estimates for the three years preceding the referendum are not distinguishable from zero, strongly supporting the assumption of no pre-trends. However, there is a clear break in the trend in applications from international students from EU countries surrounding the referendum –a trend that prevails during the three successive years. The persistence of

[21] For consistency with our preferred specification, we control for the size of the population of age 15 to 19 in the source country by year and use the value of this variable measured at the beginning of our period of analysis as a weight.

the plotted negative impact is suggestive of EU students' preference to pursue their studies in the United Kingdom significantly changing on account of Brexit.

7. Heterogeneous Impacts

Thus far, the empirical evidence points to Brexit significantly curtailing international student applications to UK universities. As noted in the conceptual framework, Brexit might have also had a differential or heterogenous effect across subjects and universities based on their selectivity. Specifically, students applying to STEM programs, which have received much attention from policymakers in response to increased industry labor demands,[22] along with relatively skilled students applying to more selective universities, might enjoy additional schooling options. If they can complete their studies somewhere else, where their future employment prospects have not been hindered by a recently curtailed ability to remain in the country upon completion of their studies, they may be less enticed to apply to UK universities. In that case, applications might have selectively declined to a greater extent among more qualified or sought-after students.

The estimates in Table 5 test that hypothesis. As predicted, Brexit appears to have had a larger impact on the growth rate of EU applications in STEM (17 percent reduction)

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

when compared to non-STEM (13 percent drop).[23] As indicated by the *p*-values of the difference between groups, we can reject the null hypothesis of both estimates being equal. Similarly, Brexit appears to have lowered the growth rate of EU applications to selective universities by a greater extent (17 percent) when compared to non-selective institutions (by 13 percent) – a difference also statistically different from zero.[24]

In sum, Brexit has not only cut down the volume of international student applications but, in addition, it might have done so selectively, disproportionally impacting students in STEM fields or those applying to more selective institutions. The disparate impact on this group of international students can have significant implications, given the positive externalities of STEM labor on local earnings and productivity (*e.g.* Moretti, 2004a, 2004b; Kantor and Whalley, 2014; Peri, Shih and Sparber, 2015), as well as the importance of international talent on innovation and growth (*e.g.* Hunt and Gauthier-Loiselle, 2010, and Stuen *et al.*, 2012).

8. Mechanisms and Implications for Enrolment

To conclude, we explore potential mechanisms at play, to then explore if the observed reduction in applications translated into fewer international enrolments or,

[23] We follow the Joint Academic Coding System (JACS) definition of STEM subjects, which include: medicine, subjects allied to medicine, biological sciences, veterinary science, physical sciences, mathematical science, computer science, engineering and technology, and architecture, building and planning.

[24] Selective universities are defined according to the Sutton Trust group, which includes 30 universities: Bath, Birmingham, Bristol, Cambridge, Cardiff, Durham, Edinburgh, Exeter, Glasgow, Imperial College, King's College London, Lancaster, Leeds, Leicester, Liverpool, London School of Economics, Manchester, Newcastle, Nottingham, Oxford, Reading, Royal Holloway, Sheffield, Southampton, St Andrews, Strathclyde, Surrey, University College London, Warwick, and York.

rather, had no bite. To start, we focus on two potential determinants of changes in the volume of international student applications following Brexit: (1) *psychological factors* embodied in student perceptions of how pleasant their experience abroad might be, and (2) *economic factors* exemplified in student perceptions of what their chances to find employment in the United Kingdom might be after completing their studies. Both factors have been shown to be key in explaining international student flows. For instance, Hazen and Alberts (2006) note how feelings of disaffection are among the most important reasons for international students to return home. The increase in xenophobic crimes after the Brexit referendum would render support to that hypothesis (*e.g.* Devine, 2018; Carr *et al.*, 2020).

Similarly, the literature has documented how students' perceptions regarding their ability to work in the destination country after completion of their studies can impact international student enrollments. Focusing on the United States, Kato and Sparber (2013) show that H-1B visa restrictions have had an adverse impact on the quality of prospective international applicants, whereas Shih (2016) shows how a lower H-1B visa cap negatively impacted international enrolments.[25] In a similar vein, Bhagwati and Rao (1999), Chiswick (1999), and Rosenzweig (2006), among others, emphasize how international student applications are often tied to the prospect of securing employment in the destination country.

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

To gauge the role played by psychological factors, we examine if Brexit affected international student applications any differently in UK regions that voted to leave the EU, when compared to UK regions that voted to remain in the EU.[26] 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 6, Brexit seems to have had a similar impact on EU student applications in both sets of regions, suggesting that the observed reduction was driven by reasons other than the friendliness of the environment to which students expect being exposed.

Subsequently, we consider the role of other elements impacted by Brexit –such as EU students' ability to stay long-term in the United Kingdom after completing their studies. To that end, we investigate students' countries of origin, looking for traits reflective of the labor market and economic opportunities students might enjoy back home. We settle for two well-recognized and comparable traits: unemployment rate and per capita GDP.[27] If a key determinant of EU student applications to UK universities is their ability to live and work in the United Kingdom after completion of their studies, we would expect to observe a greater reduction in applications from EU students originating from countries with worse employment and economic prospects. Those

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

[27] We obtain data on unemployment rate and GDP per capita from the International Monetary Fund – World Economic Outlook Database. https://www.imf.org/en/Publications/WEO/weo-database/2020/October.

students would have been more likely to apply to a UK university with the hope of staying to live and work in the United Kingdom upon completion of their studies, when compared to students from countries with better economic and employment opportunities, who might understandably be more willing to return home.

Panels B and C in Table 6 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, and students from countries with a GDP per capita that is below the median. Similarly, in Panel C, we differentiate between students originating from countries with unemployment rates that are below the median, and students from countries with unemployment rates that are above the median.[28] While student applications dropped across the board, the effect of Brexit is twice as large among students from countries with lower per capita GDP when compared to the effect among students originating from countries with higher per capita GDP (16 percent vs. 8 percent reduction). Similarly, applications from EU countries dropped by practically twice as much among students from countries with higher unemployment rates, relative to applications from EU countries with lower unemployment rates (17 vs. 9 percent drop).[29] The effects by source country unemployment rate and GDP are suggestive of EU-students' curtailed opportunities to live and work in the United Kingdom after completing their studies as a potential cause for the observed decline in applications.

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

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

To conclude, we explore the implications of Brexit on international student enrolments. 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 model the impact of Brexit on the growth rate of international student enrolments. Table 7 displays the results of this exercise. As with applications, results are rather consistent across the three specifications. Focusing on our preferred model in column (3), we document a 9 percent reduction in international student enrolments after Brexit. In other words, Brexit appears to have lowered international student applications enough to curtail enrolments. At the same time, given that the effect on enrolment is lower than the effect on applications (9 vs. 14 percent reduction), universities might have raised admission rates because of reduced applications. After all, enrolments are the byproduct of university offers and student acceptances. If, in accordance to their exhibited application patterns, students were not more likely to accept a university offer, the lower impact of Brexit among enrolments might be reflective of an increase in admission rates by universities.

9. Summary and Conclusions

We explore the impact that the 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 14 percent when compared to the growth of international applications originating from non-EU members. This effect, which appears robust to several robustness and identification checks, seems to be larger for students pursuing STEM studies or applying to more selective universities, suggesting these students might enjoy better alternatives elsewhere. If that is the case, Brexit might be negatively impacting the selectivity of EU students applying to UK universities.

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

Lastly, we explore how changes in international student applications might have ultimately impacted international student enrolments. We find that the reduction in

student applications resulted in fewer international enrolments –even though the reduction was not seemingly as large as the one observed for applications.

In sum, as free labor mobility and employment opportunities disappear, EU students with potentially better alternatives – as in the case of STEM students or those applying to selective universities – and EU students with fewer employment options back home –for whom the ability to live and work in the United Kingdom after completing their studies might have been an important pull factor to studying in the United Kingdom, significantly curtailed their applications. The documented impacts are worrisome. They are non-negligible, ultimately reducing enrolments despite universities' apparent admission rate increase. In addition, the results are suggestive of student selection patterns that can have significant implications for innovation and economic growth. Given the contributions of international student exchanges to research, development, and growth, as well as the fact that the United Kingdom is the second most frequent destination for international students, with a non-negligible 37 percent of them originating from EU country members (HESA, 2019),[30] further research on the implications of Brexit for UK universities and the ability to attract and retain valuable talent is well-warranted.

[30] HESA. https://www.hesa.ac.uk/data-and-analysis/students/

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Table 1
Growth Rate of Applications by Student Origin

Year	Non-EU	EU
2008	-0.137	-0.117
2009	0.04	0.118
2010	0.107	0.144
2011	0.095	0.094
2012	0.051	-0.117
2013	0.087	0.092
2014	0.062	0.111
2015	0.048	0.12
2016	0.08	0.122
2017	0.041	-0.081
2018	0.14	0.022
2019	0.072	0.016
Difference 2019-2016	-0.008	-0.106
DD	-0.098	

Notes: The table shows the growth rate in applications across two consecutive years by source country, subject, and university. Each cell is weighted by the size of the population of age 15-19 in the first year (2008).

Table 2
The Impact of Brexit on EU Applications

Model Specification:	**(1)**	**(2)**	**(3)**
EUxBrexit	-0.084***	-0.080***	-0.144***
	(0.019)	(0.019)	(0.022)
DV Mean	0.033	0.034	0.034
Clusters	209	169	169
Observations	539,546	505,197	505,197
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. 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. Weights are computed as size of the population of age 15-19 measured in the first year (2013). Standard errors in parentheses are clustered at country level. Significance levels are given by: * p<0.10, ** p<0.05, *** p<0.01.

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

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Model Specification:	**Reference**	**Subject-Year**	**University-Year**	**University-Subject**	**University-Country**	**University-Subject-Year**	**Country-University-Subject**
EUxBrexit	-0.144***	-0.145***	-0.143***	-0.126***	-0.126***	-0.144***	-0.126***
	(0.022)	(0.022)	(0.021)	(0.017)	(0.017)	(0.02)	(0.017)
DV Mean	0.034	0.034	0.034	0.034	0.034	0.034	0.034
Clusters	169	169	169	169	169	169	169
Observations	505,197	505,197	504,959	505,197	505,197	503,132	505,197

Notes: The dependent variable is the growth rate in applications across two consecutive years 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, as well as the population 15-19 years old in the source country by year. All regressions are weighted by the size of the population of age 15-19 in the first year (2013). Standard errors in parentheses are clustered at country level. Significance levels are given by: * p<0.10, ** p<0.05, *** p<0.01.

Table 3B: Robustness Checks #2 – Using an Alternative Dependent Variable Specification, Control Group or Study Samples

	(1)	(2)	(3)	(4)	(5)	(6)
Model Specification:	**Reference**	**DV in Levels**	**Alternative Control Group**	**Data from 2008-**	**Excluding London**	**Excluding Zeros**
EUxBrexit	-0.144***	-0.107***	-0.140***	-0.115***	-0.159***	-0.105***
	(0.022)	(0.023)	(0.022)	(0.030)	(0.024)	(0.017)
DV Mean	0.034	2.133	0.032	0.037	0.034	0.019
Clusters	169	162	170	170	160	128
Observations	505,197	224,603	536,935	866,056	383,131	161,189
Control Group	Non-EU	Non-EU	Non-EU & British	Non-EU	Non-EU	Non-EU
Country, University, Subject Time Trends	no	yes	no	no	no	no

Notes: The dependent variable is the growth rate in applications across two consecutive years in columns (1), and (3)-(6), and the log of the number of applications in columns (2), where each cell is defined at the source country, subject, university, and year level. 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. Country, subject, and university time trends are included in column (2). All regressions are weighted by the size of the population of age 15-19 in the first year. Standard errors in parentheses are clustered at country level. Significance levels are given by: * p<0.10, ** p<0.05, *** p<0.01.

Table 4
Treatment-by-Year Analysis of Brexit on EU Applications

EUx2013	-0.036
	(0.038)
EUx2014	0.011
	(0.039)
EUx2015	0.031
	(0.036)
EUx2017	-0.166***
	(0.036)
EUx2018	-0.170***
	(0.054)
EUx2019	-0.092*
	(0.047)
Clusters	169
Observations	505,197

Notes: The dependent variable is the growth rate in applications across two consecutive years by source country, subject, and university. Leads and lags of EUxYear are equal to one in the year indicated for EU applicants, and zero otherwise. Additional regressors include an EU dummy, subject, university, and year fixed effects, as well as the population 15-19 years old in the source country by year. All regressions are weighted by the size of the population of age 15-19 in the first year (2013). Standard errors in parentheses are clustered at country level. Significance levels are given by: * p<0.10, ** p<0.05, *** p<0.01.

Table 5: Heterogeneous Effects
The Impact of Brexit on EU Applications by Subject Area and University Type

	(1)	(2)	(3)	(4)
	STEM	**Non-STEM**	**Selective**	**Non-Selective**
EUxBrexit	-0.174***	-0.126***	-0.170***	-0.132***
	(0.026)	(0.020)	(0.024)	(0.023)
DV Mean	0.052	0.021	0.048	0.024
Clusters	154	164	156	165
Observations	220,451	262,906	196,623	308,574
p-value EUxBrexit (1)=(2)	0.004			
p-value EUxBrexit (3)=(4)			0.023	

Notes: The dependent variable is the growth rate in applications across two consecutive years 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, as well as the population 15-19 years old in the source country by year. All regressions are weighted by the size of the population of age 15-19 in the first year (2013). Standard errors in parentheses are clustered at country level. Significance levels are given by: * p<0.10, ** p<0.05, *** p<0.01.

Table 6: Mechanisms
Relevance of Psychological and Economics Factors

	(1)	(2)
Panel A: By UK Region	**Leave**	**Remain**
EUxBrexit	-0.146***	-0.143***
	(0.022)	(0.030)
DV Mean	0.037	0.028
Clusters	159	163
Observations	317,408	187,789
p-value EUxBrexit (1)=(2)	0.905	
Panel B: By GDP at Origin Country	**High-GDP**	**Low-GDP**
EUxBrexit	-0.082**	-0.161***
	(0.034)	(0.025)
DV Mean	0.024	0.047
Clusters	61	112
Observations	241,921	244,936
p-value EUxBrexit (1)=(2)	0.084	
Panel C: By Unemployment at Origin Country	**Low-Unemployment**	**High-Unemployment**
EUxBrexit	-0.091***	-0.165***
	(0.013)	(0.036)
DV Mean	0.022	0.043
Clusters	52	72
Observations	208,984	206,252
p-value EUxBrexit (1)=(2)	0.020	

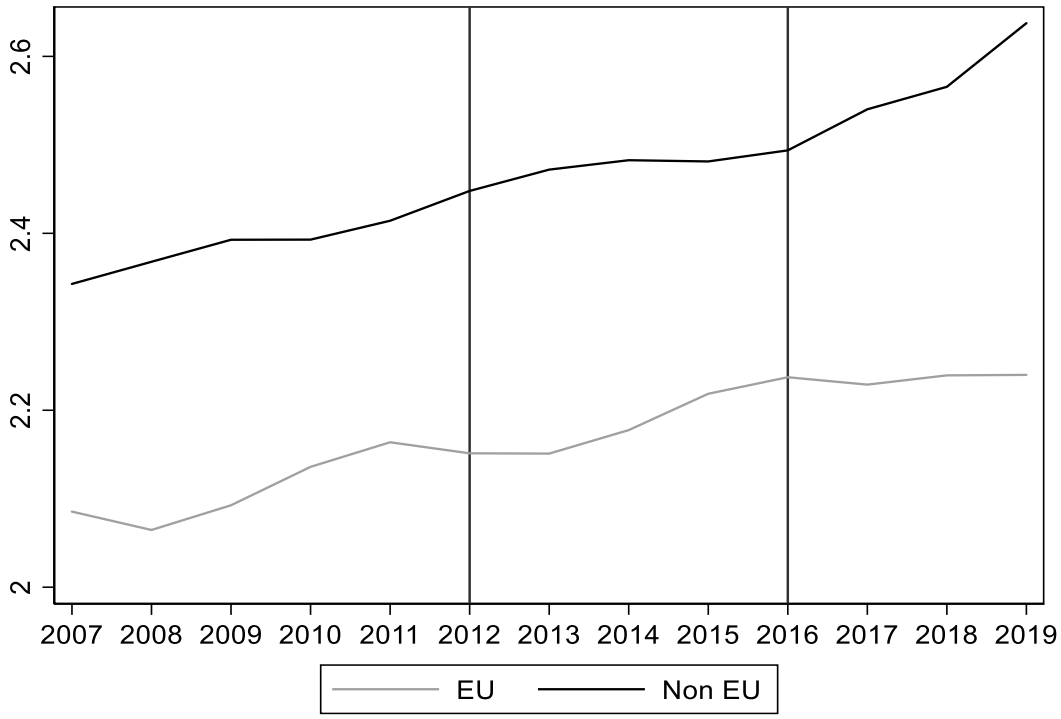
Notes: The dependent variable is the growth rate of applications across two consecutive years by source country, subject, and university. Brexit refers to an indicator set equal to one for all years after 2016. Additional regressors include an EU dummy, subject, university, and year fixed effects, as well as the population 15-19 years old in the source country by year. All regressions are weighted by the size of the population of age 15-19 in the first year (2013). **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 estimated Brexit impact 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. **Panel C** shows the results by country-of-origin unemployment rate. Specifically, column (1) shows the estimated Brexit impact for applications from countries with unemployment rate below the median value in any given year, whereas column (2) does it for applications from countries with unemployment rate above the median value in any given year. Median values are computed separately for EU and non-EU countries. Standard errors in parentheses are clustered at country level. Significance levels are given by: * p<0.10, ** p<0.05, *** p<0.01.

Table 7: Implications
The Impact of Brexit on EU Enrolments

Model Specification:	**(1)**	**(2)**	**(3)**
EUxBrexit	-0.047***	-0.046***	-0.092***
	(0.011)	(0.012)	(0.013)
DV Mean	0.016	0.016	0.016
Clusters	145	128	128
Observations	166,015	161,702	161,702
Population 15-19 in Source Country by Year	no	yes	yes
Weights	no	no	yes

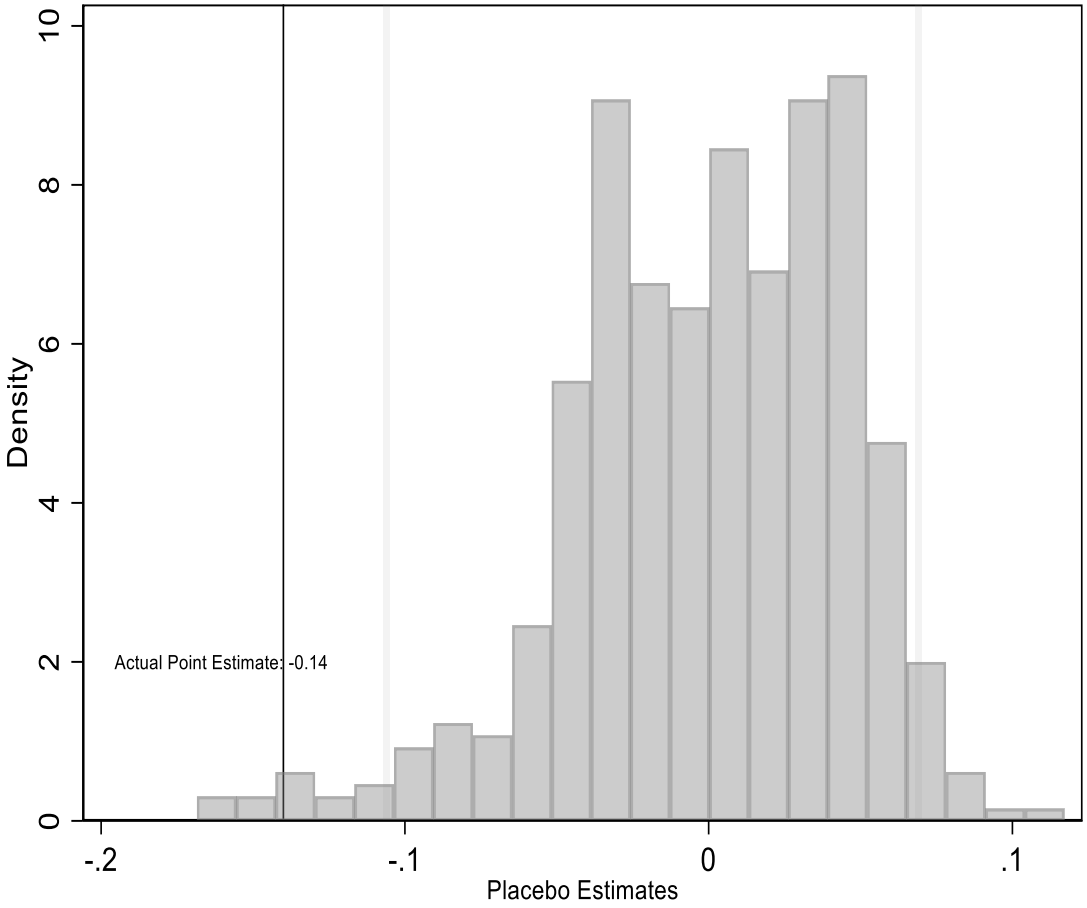
Notes: The dependent variable is the growth rate in enrolments across two consecutive years by source country, subject, and university. Brexit refers to an indicator set equal to one for all years after 2016. Additional regressors include an EU dummy, subject, university, and year fixed effects. Weights are given by the size of the population age of 15-19 in the first year (2013). Standard errors in parentheses are clustered at country level. Significance levels are given by: * p<0.10, ** p<0.05, *** p<0.01.

Figure 1
Average of (Log) Applications by Student Origin and Over Time



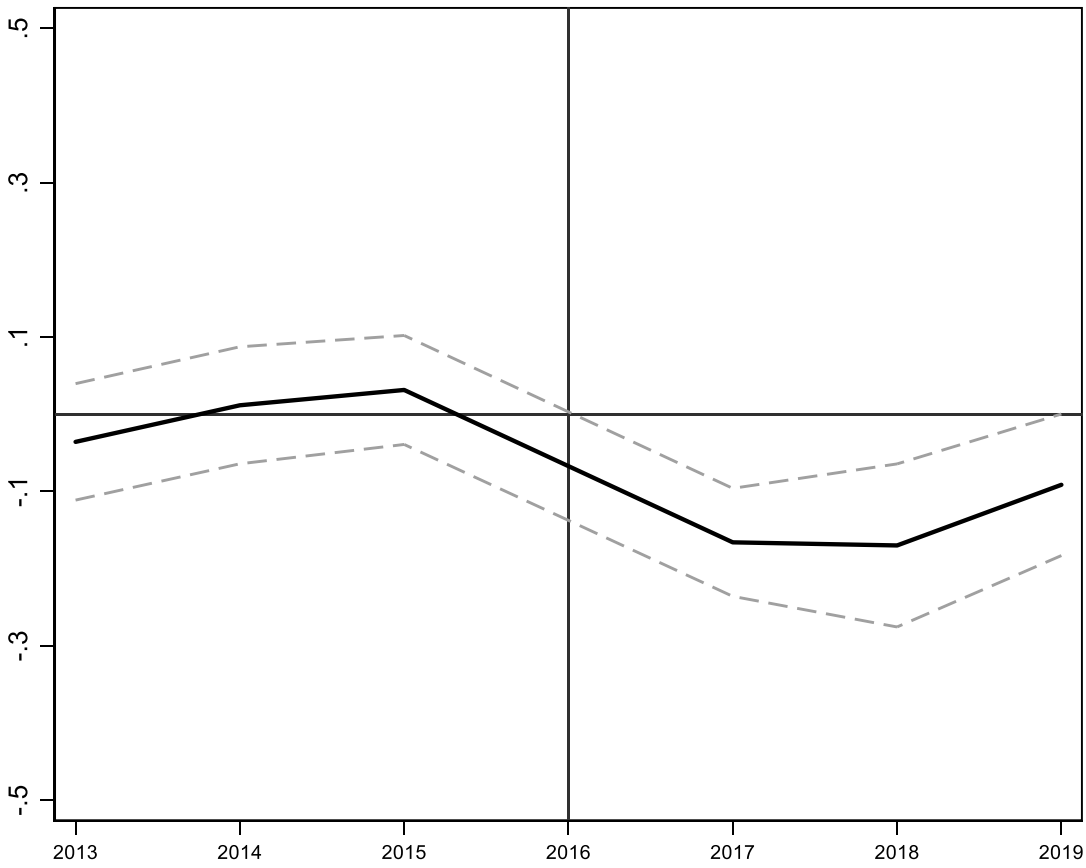
Notes: This figure shows the weighted yearly average value of log of applications by country, subject, and university, using the size of the population of age 15-19 in the first year (2007) as weight.

Figure 2
Robustness Checks: Histogram of Placebo Estimates



Notes: This figure shows the distribution of the coefficients obtained from 500 placebo regressions using the baseline specification of Table (2), column (3) 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 (3) of Table (2), whereas the two light grey lines refer to the 95 % confidence interval.

Figure 3
Treatment-by-Year Plot



Notes: The figure shows the coefficients of the interaction of leads and lags of the variable EUxYear, which is equal to one in the year indicated for EU applicants, and zero otherwise. The dependent variable is defined as in Table 4, and the specification is described in eq. (2). Additional regressors include an EU dummy, subject, university, and year fixed effects. Regression weights are given by the size of the population age of 15-19 in the first year (2013). Solid lines refer to regression coefficients, dotted lines refer to 95% confidence intervals obtained using clustered standard errors at country level.