International Peers in Higher Education and Domestic Students' Outcomes[*]

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Abstract

Recent decades witnessed a rapid increase in foreign post-secondary student enrollment in the US, substantially altering the college landscape. While evidence suggests that foreign students contribute significantly to university revenues and the host economy, there remains much debate around their impact on domestic students' outcomes. Using rich administrative and survey data from a large US public university, this paper explores the effects of exposure to foreign peers in college courses on domestic students' academic outcomes. I focus on first-term introductory math courses and leverage plausibly exogenous variation in the share of foreign peers across terms but within a course-instructor pair. I find that exposure to foreign peers in lower-ability (non-calculus) courses has a sizable negative effect on the graduation rate of domestic students; students in higher-ability (calculus-based) courses are unaffected by their foreign peers. The decline in graduation comes through a drop in students graduating with non-STEM degrees, with no effect on the number of STEM graduates. Further, the negative effects are incurred by domestic students of all races except Asians; domestic Asian students incur positive effects. Exploring potential mechanisms, I find suggestive evidence of limited interaction, lack of shared interests or culture, and language barriers between domestic and foreign students. Additionally, evidence points to the potential role of domestic students' lower academic rank in their peer group. At the same time, I do not find evidence of negative social preferences associated with races or immigrants among domestic students, nor do I find evidence linking the effect to differences in abilities between domestic and foreign students.

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I. Introduction

Recent decades saw a rapid expansion of students from foreign countries in post-secondary education (henceforth, foreign students). In the US, foreign student enrollment increased from 0.5 million in 2004 to close to 1 million in 2016, accounting for roughly 5% of total post-secondary enrollment (Institute of International Education, 2022). Existing research suggests that this influx significantly increased revenue for host universities amid declining state funding and also benefited the local economy (Bound et al., 2020; Rakesh, 2023). According to NAFSA (2020), foreign students contributed $41 billion to the US economy in the Academic Year 2018-19.[1]

Notwithstanding the sizable economic contributions, the rapid growth in foreign student presence has generated a lot of debate around their impact on domestic students' outcomes. Universities and proponents argue that foreign students provide an international and cross-cultural perspective that benefits all students.[2] On the contrary, opponents claim that foreign students negatively affect domestic students' academic outcomes. For instance, one argument posits that increased competition from foreign students affects domestic students' enrollment .[3] As a consequence, there have been calls for restrictions on foreign student enrollment.[4] Despite the extensive literature exploring the influence of peers on a wide range of outcomes across different contexts (Sacerdote, 2011, 2014), there is not much evidence on the peer effects of foreign students.

In this paper, I study the effects of exposure to foreign peers in college courses on domestic students' graduation and related outcomes. For the analysis, I use novel administrative student-level data from a large US public university that saw a drastic increase in foreign student enrollment in recent decades. Another key feature of the university that makes it apt for this study is that it is *not* "highly selective." This is important because, in a univer-

[1] To put that in perspective, the financial incentives provided by all tiers of the US government under place-based job policies was around $60 billion in 2015 (Bartik, 2020).

[2] See (Groot, 2023). This argument relates to the psychology literature on intergroup contact theory following Allport (1954), which generally documents a negative correlation between intergroup contact and prejudice (Paluck, Green and Green, 2019; Pettigrew and Tropp, 2006).

[3] See http://graphics.wsj.com/international-students/the-debate and Anderson (2016).

[4] In July 2021, the California Legislature even proposed a bill to reduce the number of nonresident University of California students (Kovach, 2021).

sity that is very highly selective, all students are likely to be of very high quality — the students are likely to enter college with high academic ability and good study habits, which may greatly reduce the potential influence of their peers (Stinebrickner and Stinebrickner, 2006). I focus on the exposure to foreign students in first-term introductory mathematics courses, which students have to take to meet the University Mathematics Requirement to graduate, irrespective of their major. Further, a range of introductory math courses by ability allows me to measure peer effects in lower-ability (non-calculus) and higher-ability (calculus-based) courses separately. I look at the effects in the two groups separately as the level of skills that affect individual performance and factors affecting collaboration or classroom dynamics could vary across the two groups, leading to distinct peer effects.

The administrative data have detailed student-level information on all students who took one of the introductory math courses between the Fall 2005-Spring 2015 semesters. The data include demographic information, background information, and academic records of the students until the end of their time at the university. My main sample includes all freshmen domestic students who were admitted in one of the fall semesters between 2005-2014 (10 years) and enrolled in an introductory math course in their first term. I proxy for the exposure to foreign peers by the share of students who are international non-residents in the students' first-term introductory math course-instructor pair. However, a major challenge in estimating the causal impact is that the share of foreign peers one is exposed to might not be random. There could be sorting of students into or out of courses, instructors, or terms due to reasons that are correlated with the foreign peer exposure and the outcome of interest. For instance, students may have a preference for particular instructors within a course, which may lead to the potential selection of students across instructors within a course.

My empirical strategy leverages the idiosyncratic variation in the share of foreign peers at the course-instructor-term (peer group) level after controlling for course-instructor and course-term fixed effects. Employing fixed effects, I leverage variation in foreign peer exposure across terms but within the same course-instructor pair.[5] This allows me to effectively

[5] This approach is similar to other studies in peer effects literature using cohort-to-cohort variation in peer composition within school-grade pair (Anelli and Peri, 2019; Bifulco, Fletcher and Ross, 2011; Carrell and Hoekstra, 2010; Gould, Lavy and Paserman, 2009; Hoxby, 2000).

compare students who enrolled in the same introductory math course with the same instructor in their first term in college, and identify using over-time variation in foreign peer exposure. This approach absorbs potentially confounding time-invariant course-instructor factors and time-varying course-level factors. The causal interpretation of peer effects in my setting relies on a conditional independence assumption: after controlling for the fixed effects, the residual variation in the foreign peer exposure across students is as good as random. I assess the validity of this assumption by conducting balance tests between students' exposure to foreign peers and their pre-determined characteristics and ability measures after controlling for the fixed effects. I also show that the residual variation is uncorrelated to the peer group characteristics, ability, and peer group size. In addition to the apt setting and the fixed effects, I include the student's predetermined characteristics and ability measures, peer group size, and the peer group characteristics and ability measures to alleviate further endogeneity concerns.

I find a sizable negative effect of exposure to foreign peers in lower-ability courses on domestic students' six-year graduation rate. On average, a 10 percentage point increase in the share of foreign peers causes the graduation rate of domestic students to decrease by 6.1 percentage points, a drop of 7.8% of the mean. In contrast, the graduation rate of domestic students in higher-ability courses is unaffected by their foreign peers. This is consistent with the hypothesis that the potential influence of peers on academic outcomes weakens with the increasing quality of students. Further, I find that the entire effect on the graduation rate comes from a negative effect on the likelihood of students graduating with non-STEM majors, thereby reducing the number of non-STEM graduates. At the same time, there is no effect on the number of domestic STEM graduates. In fact, further analysis shows that conditional on graduating, the likelihood of domestic students with a STEM major preference graduating with a STEM major increases with increased exposure to foreign peers in higher-ability courses. These results also address the concern related to foreign students potentially displacing domestic students out of STEM majors.

In addition to the balance tests, I conduct several tests to confirm the robustness of the findings. The results are consistent across a series of specifications tests, including the addition of more controls and fixed effects, using an alternate sample, and alternate variation in foreign peer exposure.

Why do foreign peers in lower-ability courses negatively affect domestic students' graduation? I explore several mechanisms through which peer effects might be operating. First, I consider whether exposure to more foreign peers negatively affects short-term outcomes, which may lead to lower graduation rates. Looking at first-year retention, I find that over 70% of students adversely affected by exposure to foreign peers drop out in their first year. I also find negative effects on math course GPA and first-term GPA. Further, as students might perceive short-run achievement as a measure of relative performance within their peer group, I explore if the effect on graduation through this channel is linked to relative performance. I include short-run achievement variables in the main equation and re-estimate the effect on graduation, further restricting the comparison to students having the same relative performance within their peer group. The point estimate drops by one-third compared to the baseline, suggesting one-third of the total effect is due to an effect on relative performance.

Second, the peer effects may be due to differences in the ability of domestic and foreign students in the lower-ability courses — the presence of more higher-ability foreign students may negatively affect the graduation of relatively lower-ability domestic students, for instance, through increased competition. If ability difference is a source of potential mechanism, one would expect to see a stronger effect on lower-ability students in the peer group. However, I find no heterogeneous effect by the domestic student's ability, as measured by ACT Math score. Further, looking at heterogeneity with within-peer-group ability bins, I find that students in the lowest quintile within a peer group are not differentially affected compared to students in the middle or highest quintiles. These results suggest that peer effects are likely not operating through ability-based mechanisms.

Third, I explore several non-ability factors as a source of potential mechanisms. These factors may alter collaboration or classroom dynamics, among other things, potentially affecting graduation. In addition to administrative data, I use unique panel data from a survey of domestic students at the university to shed light on non-ability factors. The survey includes questions about domestic students' experiences with foreign students in their first year at the university.

Examining the heterogeneous effect by the race of domestic students, I find a negative effect of exposure on domestic students of all races except Asians; domestic Asian students, in contrast, incur a positive peer effect. Given that over 90% of foreign students are Asians, this result suggests that race-related factors could be operating here. Thus, I further explore domestic students' social preferences over race and immigrants and a lack of common interests/culture between domestic and foreign students as two non-ability factors that could be driving heterogeneous effects by race and the main effect.

Exploring the survey data, I do not find evidence of social preference against interacting with foreign students — most domestic students are "looking forward" or "excited" to interacting with foreign students at the beginning of their college life. However, in the 1-year follow-up survey, I find that the actual interaction between domestic and foreign students is very limited, and one of the major reasons domestic students mention that hinders their interaction with foreign students is that they have different interests than foreign students.

The primary reason that domestic students mention that hinders their interaction with foreign students is communication due to the language barrier. Many foreign students may have limited English proficiency as most of them are non-native speakers of English. To explore this further, I look at the effect of exposure to foreign peers with high and low English proficiency on domestic students' graduation using the main data and find that the effect is driven mainly by exposure to low English proficiency foreign students.

This paper contributes to three bodies of literature in economics. First, it contributes to the literature on the effect of immigrants, particularly foreign students, on the educational outcomes of natives. Much of the past literature looks at primary and secondary education levels (Ballatore, Fort and Ichino, 2018; Betts and Fairlie, 2003; Diette and Oyelere, 2014; Figlio and Özek, 2019; Gould, Lavy and Paserman, 2009; Hunt, 2017; Ohinata and Van Ours, 2013). Studies that focus on higher education have mostly exploited university-level variation (Borjas, 2004; Hoxby, 1998; Shih, 2017). On the other hand, I exploit finer, peer group-level variation to provide evidence on the effects of foreign peers. Looking at the effects on the number of graduates by major, I further contribute to the literature exploring the effect on intensive margin outcomes (Anelli, Shih and Williams, 2023; Orrenius and Zavodny, 2015). In a related paper, Anelli, Shih and Williams (2023), using a similar methodology and focusing only on calculus courses in a "highly selective" university, find a negative impact of exposure to foreign peers on the STEM graduation of domestic students. The negatively affected students move to high-earning Non-STEM majors, leading to no effect on the overall graduation rate or future expected earnings of domestic students. In contrast, my paper focuses on all students enrolled in a university that is *not* "highly selective" and finds a negative effect on domestic students' graduation rate in non-calculus courses only; there is no effect on the overall supply of STEM graduates.

Second, this paper contributes to an extensive literature on peer effects in education. Many papers look at the peer effects of exposure to particular dimensions of diversity, for instance, race, gender, and economic status (Anelli and Peri, 2019; Hoxby, 2000; Rao, 2019). However, foreign students are different — they usually embody multiple dimensions of diversity, such as race, language, and culture, making it difficult to extrapolate findings from other contexts. Therefore, the peer effects of foreign students need to be studied separately, and my paper fills this gap in the literature. I also contribute to the literature on peer effects in higher education (Foster, 2006; Martins and Walker, 2006; Parker et al., 2010; Sacerdote, 2001; Stinebrickner and Stinebrickner, 2006; Zimmerman, 2003). While many papers in this literature find no or modest effects on academic outcomes, my paper finds a sizable negative peer effect on graduation. Further, my paper also demonstrates how with the increasing ability of the peer group, the potential influence of peer effects may decrease.

Finally, this paper contributes to the literature on diversity and desegregation. Studies find that contact substantially reduces inter-group prejudice (Boisjoly et al., 2006; Carrell, Hoekstra and West, 2019; Finseraas et al., 2019). Although my paper does not directly look at the impact on the social outcomes of domestic students, I find evidence of a lack of interaction between students of the two groups. I also find that the interaction may be happening within races only. These findings suggest that contact within peer groups may not necessarily lead to interaction. Thus, limited interaction may not improve inter-group prejudice, while at the same time, it may have a negative impact on academic outcomes, as shown in the paper.

II. Setting

The study is based at a large US public university that hosts domestic students from all 50 US states and foreign students from over 135 countries. The institution is *not* "highly selective" with an average acceptance rate of around 70% in the last 10 years, which makes it an apt choice for this study.[6] Students in "highly selective" universities are likely to be of very high quality, making them far less susceptible to incur peer effects. Those students are likely to enter college with high academic ability, good study habits, and a firm belief in the importance of college, which may greatly reduce the potential influence of their peers. This could be one of the potential reasons why many previous studies that focused on more selective universities found little evidence of peer effects on academic outcomes (Stinebrickner and Stinebrickner, 2006).[7]

Figure 1 plots the foreign and domestic student enrollment trend at the university. The total undergraduate enrollment increased steadily from 35,000 to 38,000 between 2005 and 2014. A steady decrease in domestic undergraduate enrollment and a rapid increase in foreign undergraduate enrollment led to a rapid increase in the share of foreign undergraduates from 3.5% to 14% during the period. In Fall 2014, the domestic undergraduate student body comprised of around 78% White, 8% Black, 5% Asian, and 4% Hispanic. In the same term, over 90% of the foreign students were from Asian countries, primarily from China (75%), Korea (6%), Taiwan (2%), India (2%), and Saudi Arabia (2.5%).

An undergraduate student may choose from more than 200 majors that the university has to offer. Freshmen and sophomore students can opt for an Exploratory Preference major, which allows them to explore options and choose an appropriate major that fits their abilities and interests. However, all students have to formally declare a major once they reach Junior standing (56 credits).[8] About 80% of undergraduate students graduate within 6 years of starting at the university.

To identify the peer effects of foreign students, I focus on introductory math courses. This

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[6] In recent years, the acceptance rate is around 80%. ACT and SAT ranges of admitted applicants who fell within the 25th and 75th percentile in 2022 are 23-29 and 1100-1320, respectively.

[7] See Foster (2006); Martins and Walker (2006); Parker et al. (2010); Sacerdote (2001); Zimmerman (2003).

[8] A student needs to complete 120 credits to get a degree in the majority of majors.

is because all students must meet the University Mathematics Requirement to graduate, irrespective of their major, by earning credits in one or more of these courses. Once admitted, students work with their university-assigned academic advisor and are placed into one of the introductory math courses based on the ACT/SAT Math score, Math Placement Service (MPS) Assessment score,[9] and some additional factors.[10] The idea is to enroll students in an introductory math course that is well suited to their math ability and preparedness.[11] This rough mapping of students to their first introductory math course based on their ability at the time of admission reduces the potential endogeneity issue that might arise due to choosing a particular course.

Most students enroll in the introductory math courses they are placed into in their first term, as the general recommendation from university advisors is to finish "general requirement" courses before enrolling in major-specific courses in later years. Also, introductory math courses are usually prerequisites for many other courses the students might want to take in subsequent semesters and years in the program. As most students enroll in their first introductory math course in their first term, it leads to each course having entering students with very similar math abilities, allowing me to measure peer effects in a setting where students do not differ on ability. A course may, however, have older students with lower initial math ability, but all students would have roughly a similar level of math preparedness.[12]

The set of introductory math courses a student can be placed into ranges from algebra to advanced calculus-based courses, in terms of their level of difficulty. I distinguish the set of courses into lower-ability and higher-ability introductory math courses, which include non-calculus and calculus-based courses, respectively.[13] I look at peer effects in the two groups separately as the level of skills that affect individual performance and factors affecting col-

[9] Math Placement Service Assessment is conducted by the university for entering freshmen (and some transfer students) who have been accepted to the university. The students have to take it prior to the orientation day, and the results of this assessment do not affect the status of a student's admission to the university.

[10] Some additional factors that are sometimes considered to determine math course placement are Advanced Placement (AP) math credits, International Baccalaureate (IB) math credits, or college-level math credits earned before admission.

[11] It is especially intended to warn students away from a course that is well beyond their present capabilities.

[12] All the higher-level introductory math courses have certain lower-level introductory math courses as prerequisites if you are not directly placed into them during admission. Thus, even the older students in these courses have successfully completed lower-level courses and acquired the math preparedness required to take a higher-level course, leading to all students within a particular course having roughly a similar level of math preparedness.

[13] Appendix Table A.1 lists all the introductory math courses.

laboration or classroom dynamics could be very different across the two groups, leading to different mechanisms and, therefore, distinct peer effects.

III. Data

III.A Student Admnistrative Data

This paper uses novel administrative student-level data from the above-mentioned university for the analysis. The dataset has information on all the introductory math courses offered between Fall 2005-Spring 2015 semesters and students who enrolled in those courses. For each introductory math course a student enrolls in, I observe the course name, enrollment term, and the instructor, using which I construct a roster of students for each time a course was offered by an instructor during the 10 years. The dataset includes student demographic information, background information, and detailed academic records. I follow students until the end of their time at the university. In particular, student academic records in the data include ACT scores, admit term, applicant type (first-time freshman, transfer, non-degree), GPA (term by term and overall), credits completed (term by term and overall), major preference at freshman standing, last term at the university, graduation term, and major at graduation. Student demographic and background information in the data includes sex, race/ethnicity, country of residence, US citizenship status, tuition residency, and first-generation status.

My main sample consists of first-time freshman (FTF) domestic students who enrolled in an introductory math course in their first term at the university. An FTF is a student at the university who graduated from high school but has not previously enrolled at a college, university, or any other school after high school.[14] These restrictions ensure that domestic students have not had foreign peers at the post-secondary level that influence their instructor choices. Further, I restrict the main sample to fall semester admits because the fall semester is the first term for almost all the students at this university. This leaves me with a final sample of 32,115 FTF domestic students who were admitted in one of the fall semesters between 2005

[14] A FTF student may have completed college credits while enrolled in high school.

and 2014 and took an introductory math course in their first term.[15]

I proxy the foreign peer exposure using the share of foreign students in the introductory math course a student is enrolled in. In particular, for student i, I measure the foreign peer exposure by the share of total students (excluding student i) who are international non-residents in the student i's first-term math course-instructor pair. A student is categorized as an international non-resident if they are not a US citizen or permanent resident and require a visa to study in the US. Figure 2a shows the variation in foreign peer exposure for every student in the final sample. Figures 2b and 2c show the variation in foreign peer exposure for every student in low-ability and high-ability courses, respectively. The mean exposure to foreign peers for students in the main sample in lower and higher-ability courses is 0.04 and 0.15, respectively.

Table 1, Panels A and B present the summary statistics for main sample students and their foreign peers, respectively. Column 1 shows the mean characteristics of students in lower-ability courses, column 2 shows the mean characteristics of students in higher-ability courses, and column 3 shows the mean characteristics of students in all the courses. Panel A shows that the main sample students are predominantly white in both types of courses, where their average share is 84%. Students in lower-ability courses are more likely to be Blacks, Hispanics, females, and first-generation students and less likely to be Asian compared to higher-ability courses. The mean math and English ability of students, proxied by their ACT Math and English scores, respectively, are lower in lower-ability courses than in higher-ability courses, which is expected.[16]

Panel B of Table 1 shows that a majority of foreign peers are from Asian countries, with a majority of them coming from China. The mean share of foreign peers from China is 47% and 71.4% in lower and higher-ability courses, respectively. Other major sending countries of foreign students are Korea, Taiwan, India, and Saudi Arabia. Like their domestic peers, the mean math and English ability of students are lower in lower-ability courses than in higher-ability courses. Also, on average, the foreign students are marginally better in math than the

[15] All the main sample students during the 10 years are enrolled in only one introductory math course in their first term. So, there are no multiple observations for the same student.

[16] There are a few cases with missing ACT scores in the data. In such cases, it is imputed from the SAT score or MPS Assessment Score, if available.

main sample students.

III.B Survey Data

In addition to the administrative data, I use data from a unique panel survey of domestic students at the university about their first-year experiences related to interaction with foreign students. The sample for the survey was randomly chosen from all the incoming domestic freshman students in Fall 2018. The baseline survey was conducted at the beginning of Fall 2018, and the follow-up survey was conducted in Fall 2019. The baseline survey included questions on students' beliefs and expectations about interacting with foreign students at the university, among other things. The 1-year follow-up survey included questions about their experiences with foreign students in their first year.

There are a total of 305 students who responded to both rounds of the survey, of which 74% are White, 9% are Black, and 8% are Asian. The percentage of foreign students among the total undergraduates at the university in Fall 2018 was 10% (3,862 out of 38,701 students), whereas the share of foreign students among the entering freshman was 8.6% (737 out of 8500 students). Although the survey period does not overlap with the period of administrative data used in this paper for the main analysis, the two samples are fairly comparable, and it is reasonable to use the survey data to shed light on the underlying mechanisms and complement the main analysis.

IV. Econometric Framework

IV.A Empirical Strategy

To identify the peer effects, I leverage the idiosyncratic variation in the share of foreign peers at the course-instructor-term (peer group) level after controlling for course-instructor and course-term fixed effects. This means that I am comparing students who enrolled in the same introductory math course with the same instructor in their first term in college, and identifying using over-time variation in foreign peer exposure. This approach absorbs potentially confounding time-invariant course-instructor factors and time-varying course-level factors.

Essentially, I try to replicate an ideal experiment where students are exposed to a random share of foreign peers in their peer group while everything else about their peer group is the same.

Formally, I estimate the impact of exposure to foreign peers using the following empirical specification:

$$Y_{icjt} = \alpha + \beta \times Foreign\ Share_{icjt} + \theta_{cj} + \lambda_{ct} + \gamma X_i + \delta G_{cjt} + \epsilon_{icjt} \quad (1)$$

Y_{icjt} denotes an outcome of student i, in introductory math course c, with instructor j, in term t. $Foreign\ Share_{icjt} = \frac{\sum_{k \neq i} FS_{kcjt}}{n_{cjt}-1}$ is the proportion of students in student $i's$ peer group (except student i) who are foreign. FS_{kcjt} is a dummy variable that takes a value of 1 if the student k in student $i's$ peer group is foreign, and 0 otherwise. n_{cjt} is the peer group size of the student i. I measure the foreign peer exposure at the course-instructor-term (peer group) level as opposed to the course-instructor-term-section (classroom) level due to the potential nonrandom selection of students into sections within a course and instructor.[17] θ_{cj} is course-instructor fixed effects, and it controls for fixed differences across course-instructor combinations that may lead to endogenous sorting of students. λ_{ct} is course-term fixed effects, and it accounts for time-varying course-level factors. X_i is a set of student i's pre-determined characteristics, including race, gender, first-generation indicator, Math, and English ability. G_{cjt} controls for peer group level characteristics, including average peer math ability, the share of females, and the share of first-generation students. ϵ_{icjt} is the error term. I cluster the standard errors at the instructor level.

IV.B Identification

There are three major identification concerns that are well documented in the peer effects literature: reflection, selection, and common shocks. The reflection problem arises when the simultaneous determination of student and peer outcomes leads to difficulty disentangling the effect that the peers have on the student from the effect the student has on the peers

[17] This equation is essentially a reduced-form instrumental variables equation where the exposure to foreign students at the peer group level instruments for exposure to foreign students at the classroom level. In a robustness test, I estimate the structural IV estimate and find similar results.

(Manski, 1993). This is usually an issue when contemporaneous outcomes of peers are used as a main explanatory variable. However, I use the share of foreign peers in the peer group as the main explanatory variable, and being foreign is determined exogenously before the students enrolled in college; reflection is not an issue here. My approach is similar to studies where variation in predetermined measures of peers is used as a proxy to their contemporaneous outcomes to resolve the reflection problem (Figlio, 2007; Hoxby, 2000; Hoxby and Weingarth, 2005; Imberman, Kugler and Sacerdote, 2012; Lavy and Schlosser, 2011; Lavy, Paserman and Schlosser, 2012).

Selection can be an issue if students sort themselves into peer groups due to reasons that may be correlated with the outcome of interest. Such endogenous sorting may bias the result and make it difficult to determine the causal effect of the peers. In this particular context, there may be a problem if there is a selection of students into or out of courses, instructors, or terms due to reasons that are correlated with foreign peer exposure and the outcome of interest. However, I take several measures that make it unlikely for the estimates to be biased due to selection issues in my setting. First, I only focus on FTF students and their first-term course-taking, which ensures that the main sample students have not been exposed to foreign peers at the college level before, and are unlikely to have much knowledge of how foreign peer exposure might affect them at the college level. Moreover, the students, with guidance from a university-assigned academic advisor, enroll in their first-term courses even before they are physically present on the college campus. This further suggests that the students are likely to have very limited knowledge about instructors, courses, and the student composition in each of the course-instructors combinations while enrolling for the first-term courses.

Second, based on the ACT Math score, MPS Assessment score, and the recommendation from the academic advisor, the students are placed into their first math course. This makes it difficult for the students to select into and out of the first math course. Third, there may be sorting of students across instructors within a course, which may lead to selection bias. For instance, some domestic students might have a preference to enroll in classes with American instructors, which may be correlated to their foreign peer exposure and their subsequent outcomes. However, my identification strategy controls for course-instructor fixed effects and relies on the variation in the share of students who are foreign within the instructor and course, but across terms. This resolves the concerns related to the selection into and out of instructors as well as courses.

Finally, of critical importance to our identification strategy is that there is no endogenous sorting of students across terms within a course-instructor depending on the foreign peer exposure. Recall that the students, after getting admission to college, get placed into first-math courses based on their pre-college math ability and recommendations from the academic advisor. And, most students get enrolled in the first math course in their first term only. Further, for there to be endogenous sorting of students over terms within a course-instructor in my setting, the students would have to change their year of enrollment as we focus on the fall-enrolled students' first-term course-taking only, which seems very difficult. Moreover, the schedule of courses offered and information on instructors is not available one year in advance, which makes it even more difficult for students to delay their enrollment if they want to base their decision on the possibility of the same course being offered by the same instructor in the following year.

Common shocks or correlated effects can be a problem for identification when students and their peers share common treatments — it is often difficult to disentangle the peer effects from other shared treatment effects. They are more likely to be a problem if one uses contemporaneous peer achievement, as both student and peer achievement may be affected by the common shocks (Lyle, 2007). So, common shocks are less likely to confound the estimates in this paper because I use a pre-determined measure of peers to identify the peer effects. Moreover, controlling for course-instructor and course-term fixed effects should absorb most of the common shocks. For common shocks to be a problem in my particular setting, it has to vary within the course-instructor and should be correlated to the share of foreign students, which seems unlikely. Nonetheless, I control for individual characteristics of students and peer group-level characteristics to alleviate further concerns.

The causal interpretation of peer effects in my setting relies on a conditional independence assumption: after controlling for the fixed effects, the residual variation in the foreign peer exposure across students is as good as random. All the measures I take should alleviate the causal identification concerns; nevertheless, I conduct balance tests to examine the plausibility of this assumption. Before I look at the formal tests, I look at the raw correlation between student characteristics and foreign peer exposure without any fixed effects in Table 2, Panel A. Each column shows a coefficient from a separate regression corresponding to a different student characteristic, including demographic and academic ability. In Table 2, Column 1, I regress the dummy for if the student is White on the share of foreign peers, and the estimated coefficient is -0.007, implying that a 10 percentage point increase in the share of foreign students in the peer group is associated with a 0.7 percentage point decrease in the probability of being White. All the coefficients in Panel A similarly suggest that without accounting for the systematic differences across students through the inclusion of fixed effects, certain types of students are exposed to a higher share of foreign peers. For instance, the results show that domestic students who are exposed to a higher share of foreign peers are less likely to be White and more likely to be Asian. This could happen if students are more likely to enroll with instructors of their race, i.e. if White students are more likely to enroll with White instructors, Asian students are more likely to enroll with Asian instructors, and foreign students, a large percentage of whom are Asians, are more likely to enroll with Asian instructors. So, assuming that students who choose to enroll with an instructor of their race do better academically than when enrolled with an instructor of a different race, we may incorrectly attribute the lower academic achievement to foreign peer exposure without controlling for the fixed effects.

Next, I conduct a balance test for selection by examining whether predetermined characteristics of the main sample students are correlated to the share of foreign students after including course-instructor and course-term fixed effects. Specifically, I estimate the following equation:

$$X_i = \alpha + \beta \times Foreign\ Share_{icjt} + \theta_{cj} + \lambda_{ct} + +\epsilon_{icjt}, \tag{2}$$

where X_i is a pre-determined characteristic of student i, $Foreign\ Share_{icjt}$ is the foreign peer exposure of student i, and θ_{cj} and λ_{ct} are the two fixed effects from the main specification. Table 2, Panel B reports the estimates of β, where each column is for a separate regression corresponding to a different student characteristic mentioned in the column head. I find that once I account for systematic differences through the inclusion of fixed effects, foreign peer exposure is uncorrelated to the observed pre-determined characteristics of the students — the estimates of β are very close to zero and are not statistically significant at any conventional level of significance. Hence, it is reasonable to assume that the residual variation in foreign peer exposure is also orthogonal to the unobserved student characteristics.

I conduct a similar balance test for common shocks as well by examining whether the average characteristics of students at the peer group level are correlated to the share of foreign students. Specifically, I collapse the data to the peer group level and estimate the following equation:

$$PG_{cjt} = \alpha + \beta \times Foreign\ Share_{cjt} + \theta_{cj} + \lambda_{ct} + +\epsilon_{cjt}, \tag{3}$$

where PG_{cjt} is the average characteristics of the peer group, including the peer group size. $Foreign\ Share_{cjt}$ is the share of students who are foreign in the peer group. I again include the two fixed effects from the main specification. Appendix Table A.2 reports the results of this test. The estimates of β for each column, except the average math ability, are not statistically significant, and the magnitudes are small. Although the estimate for average math ability is significant, the magnitude is too small to make any meaningful difference in the peer group.

Finally, I also conduct a balance test of selection for foreign peers in the peer group. The composition of foreign peers could be changing over time, in which case, what I estimate is not just the effect of the increased exposure to foreign peers, but also the effect of their changing composition. Thus, to ensure that I am not picking up the effect of the changing composition of foreign peers, it is important that the composition of foreign peers is not systematically correlated with the share of foreign peers after controlling for the fixed effects. I estimate equation 2 using the sample of foreign peers instead of the main sample students and examine if the pre-determined characteristics of foreign peers in the peer group are correlated to the share of foreign students in the peer group. I divide the sample of foreign peers into two groups for this exercise. The first group is the 'main sample equivalents,' which includes foreign peers who are FTF and are in the peer group in their first term at the university. All foreign peers not in the first group belong to the 'other foreign peers' group.[18]

[18] 'Other foreign peers' includes, for example, an FTF foreign peer who is in the peer group in their second year at the university. Another example would be a foreign peer in the peer group who is a transfer student.

I divide the sample of foreign peers into two groups as students in each group are likely to have their network of peers within their respective groups, leading to potential selection by these groups. For the balance test, I primarily focus on the country of origin and the math ability of the foreign peers, in addition to other demographic characteristics. The results from this exercise are reported in Table 3, and the estimates are balanced, suggesting that the estimated peer effects in this paper are not biased due to the potential compositional change of foreign students over time.

The balance tests increase our confidence that the residual variation in foreign peer exposure is as good as random.[19,20] To further limit the scope of potential bias due to selection and common shocks, I include individual characteristics of students and peer group-level characteristics as controls in the preferred specification. Therefore, the estimates in this paper can be interpreted as causal peer effects.

V. Empirical Results

V.A Impact on Graduation

I first estimate models of domestic students' graduation rate on exposure to foreign peers, using a variety of control sets and fixed effects. Table 4 reports the results using various specifications of Equation 1, where all columns in Table 4, Panel A do not include the fixed effects, whereas all columns in Table 4, Panel B include the course-instructor and course-term fixed effects. In both panels, moving from column 1 to column 6, I sequentially add the following controls: individual characteristics, individual math ability, peer group size, average peer group characteristics, and average peer group math ability. I posit that if the residual variation in the share of foreign peers after including the fixed effects is exogenous to individual achievement, then the magnitude of estimated coefficients should remain relatively unchanged as we sequentially add more controls that are known to impact individual

[19] I also conduct a balance test on domestic students not in the main sample using equation 2 and report the results in Appendix Table A.3. Further, I conduct a balance test on main sample students by course type separately and report the results in Appendix Table A.4. All the estimates look balanced.

[20] Appendix Figure A.1 shows the residualized variation in foreign peer exposure for main sample students.

achievement. In contrast, if the magnitude of estimated coefficients changes with the addition of individual and peer group-level controls, then one might be concerned that the proposed identification strategy does not fully address the endogeneity issues.

In Column 1 of Table 4, Panel A, I simply regress the dummy for if the student graduated or not on the share of foreign peers, and the estimated coefficient is 0.13, suggesting that the likelihood of the student graduating increases with increased exposure to foreign peers. However, as I sequentially add individual and peer group-level controls, the estimated coefficient drops substantially and changes sign. The movement in the point estimates across specifications in Panel A demonstrates the extent of endogeneity problems discussed earlier and how without addressing them, the estimated coefficients can be biased and misleading.

Each column in Panel B, Table 4 reruns the regression from the corresponding column of Panel A, controlling for course-instructor and course-term fixed effects. The estimated coefficients remain very stable at around -0.11 as I sequentially add individual and peer group-level controls between column 1 and column 6. This is strong evidence that the variation in exposure to foreign peers after controlling for fixed effects is exogenous to individual academic achievement, and the estimates can be interpreted as causal rather than being driven by selection or common shocks.[21]

The preferred specification is Column 6 in Table 4, Panel B, which includes both the fixed effects and a long list of individual and peer group-level controls that are known to affect individual academic achievement. The result from the preferred specification implies that a 10 percentage point increase in the share of foreign students in the peer group causes the graduation rate of domestic students to decrease by 1.1 percentage points, and the estimate is statistically significant at the 10% level.

Now, I look at the causal effects of exposure to foreign peers on the six-year graduation rate of domestic students enrolled in lower and higher-ability introductory math courses in their first term at the university using the preferred specification, and the estimates are reported in Table 5. Column 1 in Table 5 replicates the estimate from column 6 of Panel B, Table 4. In Column 2, I find a large negative effect on the graduation rate of domestic students en-

[21] The results for the same exercise using the sample by course type are reported in Table A.5.

rolled in lower ability courses — a 10 percentage point increase in the share of foreign peers decreases the graduation rate by 6.1 percentage points, which is statistically significant at the 1% level. Given the average six-year graduation rate is 78% in lower-ability courses, this is a drop of 7.8% of the mean. In the higher-ability courses, there is no effect of exposure to foreign peers on the graduation rate of domestic students — the point estimate is very close to zero and not statistically significant at any conventional level.

V.B Robustness

Alternative Specifications.— I conduct a battery of robustness tests to confirm the tenor of the results in the previous section. The first potential concern is that classroom-level characteristics that are known to impact student academic achievement could be correlated to the main treatment variable, the share of foreign peers at the peer group level, and not controlling for them could bias the estimates.[22] To test this, I re-estimate the peer effects, additionally controlling for classroom-level shares of female students and first-generation students, average math ability in class, and class size. Results are robust to this inclusion and are reported in Table 6, Column 2.

Second, unlike in schools where all students take the same set of courses, at the college level, students enrolled in the same math course could be enrolled in different first-term courses. If the share of students in a math course enrolled in a particular set of other first-term courses is changing over time, it could bias the estimates. To address this concern, I include Freshman Major fixed effects, which essentially restricts the comparison to students pursuing the same major and who are likely to be enrolled in the same set of other first-term courses. The results are consistent and are reported in Table 6, Column 3. Third, I restrict the sample to the most basic math course (College Algebra), where a large majority of students are FTF who are taking the course in their first term at the college — endogenous sorting of other students in the peer group not in their first-year is less of concern in this course.[23] The results are consistent with earlier findings; in fact, the point estimates are marginally higher

[22] Recall that an instructor might be teaching multiple sections of the same course in a term, and we only control for course-instructor-term level characteristics in our preferred specification.

[23] This exercise is only relevant for the lower-ability courses sample.

than the baseline results (Table 6, Panel A, Column 4).

Fourth, another concern could be that the foreign students' math ability could be changing over time, and just controlling for the average ability of the peer group might not fully capture it. Although I did not find a sizable correlation between the share of foreign students and the math ability of foreign students in the balance test earlier, it is still a potential concern — I might be picking up the effect of changing ability of foreign students overtime through the exposure to foreign peers, thereby overestimating the true impact of foreign peers on domestic students. To address this, I separately control for the average math ability of domestic students and foreign students within the peer group and re-estimate the peer effects. The results are very similar to our baseline specification (Table 6, column 5), thus suggesting that I am not picking up the effects of potentially changing foreign students' math abilities. Finally, there could be sorting of foreign and domestic students by class-session timings, which could bias the estimates. So, I additionally control for the class-session time dummy and re-estimate the peer effects. Specifically, I include a dummy variable that takes a value of 1 if the student was enrolled in an introductory math class with sessions starting before noon, and 0 otherwise. Results are robust to this inclusion and are reported in Table 6, column 6.

Class-level Variation and Instrumental Variable Analysis.— In the main specification, I use variation in exposure to foreign peers at the course-instructor-term (peer group) level instead at the course-instructor-term-section (class) level, which one might argue is the actual peer group of a student. I did this to primarily avoid the endogeneity concerns due to selection into and out of a section within a course-instructor during a term. To address this concern, I re-estimate a specification where the treatment variable is the share of foreign peers at the class-level. However, this could be endogenous, so I instrument it with the share of foreign peers at the course-instructor-term level, the main treatment variable in my preferred specification, which is plausibly exogenous after controlling for the fixed effects. Results from the IV estimation are reported in Column 7 of Table 6, and they are consistent with our previous findings, thus showing the robustness of our results.

V.C Impact on Major Choice and Major Switching

To further understand what is driving the decrease in graduation rates for domestic students exposed to foreign peers, I consider the likelihood of domestic students graduating with certain majors. Science, Technology, Engineering, and Math (STEM) education has been linked to key drivers of growth and innovation (Griliches, 1992; Peri, Shih and Sparber, 2015); however, recent decades have seen a drop in the share of students graduating in STEM fields. Evidence suggests that students with STEM major preference either drop out or end up switching to non-STEM majors (Chen, 2013). In regard to this, I examine if increased exposure to foreign peers negatively affects the likelihood that domestic students graduate with a STEM/non-STEM degree, thereby reducing the overall graduation rate.

I look at two major choice outcomes: STEM graduation and Non-STEM graduation. The first outcome, STEM graduation, takes a value of 1 if the student graduates with a STEM degree within 6 years of being admitted to the university, and 0 otherwise. Similarly, the second outcome, Non-STEM graduation, takes a value of 1 if the student graduates with a Non-STEM degree within 6 years of being admitted to the university, and 0 otherwise. Using the main equation 1, I estimate the effect on both the outcomes and report the results in Table 7.

I find that there is no effect of increased exposure to foreign peers on the likelihood that domestic students graduate with STEM degrees either in lower or higher-ability courses, thereby not affecting the supply of domestic STEM graduates. This result addresses the concern that foreign students crowd out domestic students from STEM majors. However, increased exposure to foreign peers in lower-ability courses leads to a significant decline in the likelihood that domestic students graduate with a Non-STEM degree. A 10 percentage point increase in the share of foreign peers leads to a 7.8 percentage point decline in the supply of domestic Non-STEM graduates, a decrease of 15% that is statistically significant at the 5% level. There is no effect on the supply of domestic non-STEM graduates in the higher-ability courses.

So far I do not find evidence of peer effects in higher-ability courses. It could be that the students in those courses are incurring peer effects, but not on the graduation as an outcome — it is less likely that the students placed in a higher-ability introductory math course do not graduate. Perhaps, there might be an effect on the major choice of these students — a student might switch from a major with a large share of foreign students to one with a lower share of foreign students, which might increase the likelihood of graduation. To explore this further, I consider if domestic students switch their previously declared major preference and graduate with another major when exposed to foreign peers. Using the sample of students who graduated in 6 years, I look at the following outcomes: STEM to Non-STEM major switch, Non-STEM to STEM major switch, and Exploratory to STEM major switch. The first outcome, STEM to Non-STEM major switch, takes a value of 1 if the student had a STEM freshman major preference but graduated with a Non-STEM major, and 0 otherwise. Similarly, I construct the other two outcomes.

The results from this analysis are reported in Table 8. I do not find a significant effect on major-switching in the lower-ability courses. However, there is a substantial major-switching activity in the higher-ability courses. I find that the likelihood of domestic students with STEM freshman major preference graduating with a STEM major increases with increased exposure to foreign peers (Table 8, Column 4). A 10 percentage point increase in the share of foreign peers reduces the switching away of domestic students from STEM majors by 1.4 percentage points, which is significant at the 5% level. This result further addresses the concern regarding foreign students displacing domestic students from STEM majors. At the same time, there is reduced switching of domestic students with Non-STEM freshman major preference to STEM majors when exposed to an increased share of foreign students. The results suggest how reduced switching out of STEM majors and reduced switching in STEM majors may lead to no effect on the supply of domestic STEM and non-STEM graduates due to exposure to foreign peers in higher-ability courses.

VI. Heterogeneity

The findings so far show that exposure to foreign peers negatively affects domestic students in lower-ability courses, on average. In an attempt to learn if these negative effects are incurred by certain sub-groups of domestic students more than other sub-groups, I look at the heterogeneity by some of the predetermined characteristics of students. Doing so may provide insights into the potential mechanisms driving the results and how to combat these negative peer effects.

Differential Effects by Math Ability.— Although the impact of exposure to foreign students in lower-ability courses is substantial, it could be even more pronounced among students with relatively lower abilities within these lower-ability courses. To explore this possibility, I look at the heterogeneity by the math ability of domestic students. For this analysis, I standardize students' math ability within the type of course and include the standardized math ability and its interaction term with the foreign share in the main specification. Table 9, Panel A, Columns 1 and 2 present the results from this exercise for lower ability and higher ability courses, respectively. I find no differential effects by the math ability of domestic students within lower or higher-ability courses.

Differential Effects by Race.— To examine the heterogeneity of peer effects by race, I include the interaction of race dummies with the foreign share. The base group is White, and the results are reported in Table 9, Panel B. I find that there is no differential effect on domestic students of any race except Asians in lower-ability courses. Interestingly, for Asian students, increased exposure to foreign peers leads to a positive effect on their graduation rate. Combining the coefficients on the main treatment variable and its interaction term with the Asian dummy implies that a 10 percentage point increase in the share of foreign peers causes the graduation rate of Asian domestic students to increase by 12 percentage points. Given that over 90% of foreign peers are Asians, the results suggest that race-related factors might be potential channels through which peer effects are operating, where domestic students of different races than their foreign peers are negatively affected, but domestic students of the same race as foreign peers incur positive peer effects.

Differential Effects by Freshman Major Preference.— To consider whether students respond differentially to foreign students based on their major preference, I examine the heterogeneity of peer effects by the major preference declared by the student at the beginning of college. Students with a STEM/Non-STEM preference might differ from those with an Exploratory preference in ways that could affect their response to increased exposure to foreign peers in introductory math courses. For instance, students with a major preference might have stronger beliefs about completing the degree they like compared to students with no major preference, leading to differential responses to exposure to foreign peers and differential effects on outcomes.

For the analysis, I construct the following three variables: STEM preference, Non-STEM preference, and Exploratory preference. The first variable, STEM preference, takes a value of 1 if the student had a STEM freshman major preference, and 0 otherwise. Similarly, I construct the other two variables based on the student's freshman major preference. Keeping the Non-STEM preference as the base group, I include the remaining two variables and their interaction term with the foreign share in the main specification. Table 9, Panel C reports the results of this analysis. I find that there is no differential effect across students who declared a major preference. At the same time, the negative effect is stronger for students who did not have a major preference and opted for the Exploratory option. The result implies that a 10 percentage point increase in the share of foreign peers causes the graduation rate of domestic students without any major preference to drop by 11.9 percentage points.

VII. Potential Mechanisms

Why do foreign peers in lower-ability courses negatively affect domestic students' graduation? Figure 3 presents a stylized diagram to describe various possible channels through which exposure to foreign peers could affect domestic students' outcomes. Channels could arise from differences in ability between foreign and domestic students. For instance, having more foreign peers of higher ability in a peer group may affect the relative performance of domestic students, which in turn may affect their graduation outcomes. Alternatively, instructors may teach at a higher level in the presence of higher-ability foreign students, affecting the domestic students' engagement, learning, or grit, which in turn may affect their graduation. Various channels could stem from other non-ability factors as well. For instance, factors like cultural distance between domestic and foreign students, social preference over race, and limited English communication skills of foreign students may hinder collaboration among students or affect the classroom environment, which in turn may affect the achievement and graduation of domestic students.

Disentangling each mechanism is difficult, given the empirical setting and the available data. Thus, I try to provide suggestive evidence on the potential mechanisms through which the peer effects might operate.

VII.A Impact on Short-Run Outcomes: Achievement and Retention

The effect of foreign peers in first-term math courses on domestic students' graduation rate, which is an eventual outcome, may be due to an effect on their short-run outcomes. For instance, lower grades in introductory math courses or first term may discourage students or put them on a path where they are less likely to graduate. Thus, I explore the effect on short-run outcomes that may affect the eventual outcomes. Specifically, I look at three outcomes: first-term math course GPA, first-term GPA, and retention rate. Both GPA variables range from 0 to 4. Retention rate is a binary variable that takes a value of 1 if the student returned in the Fall semester following the first year and 0 otherwise. It is a standard measure of student success that university administration uses, and it will help to identify that the large negative effect we see on the graduation rate is driven by students dropping out soon after the exposure or later.

Using the main equation 1, I estimate the effect on the short-run outcomes and report the results in Table 10. Increased exposure to foreign students in lower-ability courses negatively affects the short-run grades. A 10 percentage point increase in the share of foreign students in the introductory math course peer group decreases domestic students' GPA in that course by 0.16, a 6.1% drop, which is significant at the 10% level (Column 1). Also, the first semester GPA drops by 2.8%, which is significant at the 5% level (Column 2).

There is a strong negative effect on retention as well in lower-ability courses. A 10 percentage point increase in the share of foreign students in introductory math courses leads to a 4.4 percentage point drop in the retention of domestic students, which is significant at the 5% level (Column 3). The effect size on retention is larger than 70% the effect size on graduation, suggesting that among the domestic students who do not graduate due to exposure to foreign students, a majority of them drop out in the first year. In higher-ability courses, there is no effect on short-term achievement (Columns 4-5). On retention, although the effect is negative and significant at the 10% level, the effect size is too small.

Students might perceive short-run achievement as a measure of their relative performance within their respective peer groups, and a negative effect on relative performance might lead to an adverse effect on their graduation, as literature has shown that academic rank affects academic choices and outcomes (Cicala, Fryer and Spenkuch, 2018; Elsner and Isphording, 2017; Elsner, Isphording and Zölitz, 2021; Murphy and Weinhardt, 2020). Alternatively, it could be because of an effect on absolute learning or other reasons, such as domestic students' dislike for the changed classroom environment with an increased share of foreign students. To investigate if graduation effects through this channel are linked to relative performance, I include short-term achievement variables into the main equation 1 and re-estimate it. This approach examines the effect of foreign peer exposure on domestic students' graduation when they have similar relative rankings within their peer groups based on short-term achievement. Table 11 presents the findings, revealing that after accounting for relative performance, the effect on graduation amounts to two-thirds of the main effect (Column 1). This result suggests that one-third of the total effect can be attributed to an effect on relative performance.

In summary, the results in this sub-section provide three interesting findings. First, a large share of students who do not graduate due to exposure to foreign students in lower-ability courses drop out in the first year. Second, a negative effect on short-run achievement is likely to be a mechanism leading to a negative effect on graduation. Third, one-third of the total effect can be attributed to an effect on the relative performance of students; the rest is due to an effect on absolute learning or due to other potential mechanisms, for instance, due to an effect on the classroom environment that may directly affect students' graduation.

Although grades in introductory math courses and the first term could be driving effects on domestic students' graduation, they could also be interpreted as intermediate outcomes of exposure to foreign peers. Therefore, I further explore mechanisms that may be driving the main results through an effect on short-run outcomes or through other potential channels.

VII.B Ability-Based Mechanisms

Potential mechanisms may originate from ability differences between domestic and foreign students. Within lower-ability courses, the average math ability of foreign peers is marginally higher than the main sample students (Table 1). Thus, it is possible that higher-ability foreign peers negatively affect lower-ability domestic students in these courses, for instance, through increased competition. In that case, it is likely that domestic students with relatively weaker math abilities than their domestic peers should be impacted more within lower-ability courses.

While I do not find a differential effect by domestic students' math ability in lower-ability courses in earlier estimates, it is worth considering whether the estimate at the mean masks effects at the lower end of the ability distribution. In order to further examine ability-based mechanisms, I create quintiles of math ability within each course-instructor-term (peer group) and construct dummy variables (Q1-Q5), one for each quintile. For example, Q1 gets a value of 1 if a student lies in the lowest quintile of the math ability distribution of their peer group and 0 otherwise. Similarly, Q5 gets a value of 1 if a student lies in the highest quintile of the math ability distribution of their peer group and 0 otherwise. First, I control for the quintile groups and keep the highest quintile group (Q5) as the omitted group. Table 12, Column 1 shows that after controlling for the quintile groups, the points estimates are virtually unchanged.

I then look at the heterogeneous effects by quintile groups, keeping the highest quintile group (Q5) as the omitted group, and report the results in Table 12, Column 2. I find that there is no differential effect on domestic students belonging to the lowest quintile (Q1) of the math ability distribution of their peer group. In fact, students in none of the quintile groups are differentially affected. Overall, the results in this subsection provide suggestive evidence that the peer effects are likely not operating through ability-based mechanisms.

VII.C Non-Ability-Based Mechanisms and Survey Evidence

I do not find evidence that the peer effects are operating through ability-based mechanisms, which suggests the importance of non-ability factors. Also, the earlier result on heterogeneous effects by race further emphasizes the importance of mechanisms stemming from non-ability factors. In addition to administrative data, I draw on unique panel data from a survey of domestic students at the university (described in Section III.B) to shed light on the role of non-ability-based mechanisms.

Given that most foreign students are Asians, negative effects on domestic students of all races except Asians and a positive effect on domestic Asian students suggest that race-related factors might be playing a role. These observed effects could be because of homophily, i.e., the tendency of people to associate with similar others. Evidence suggests that homophily in race creates the strongest divides in personal environments, leading to significant social segregation and shaping individuals' social interactions and networks (McPherson, Smith-Lovin and Cook, 2001). Two major factors that may induce homophily in race and potentially lead to heterogeneous effects by race in this context are 1) social preference over race/foreign students and 2) common interests/culture between domestic and foreign students. Domestic Asian students may have more common interests/culture with other foreign students of the same race. They are also likely not to have a social preference against interacting with other Asians. Therefore, having more foreign students may lead to increased collaboration or better classroom experience for domestic Asian students, potentially leading to a positive effect on their academic outcomes. In contrast, domestic White students may not have much in common with foreign students, or they might have a social preference against interacting with Asians, which may hinder their collaboration with foreign students or worsen their classroom experience, potentially leading to a negative effect on their academic outcomes. Foreign students may also feel more comfortable interacting with other foreign or domestic students of the same race.

Using the survey data, I first explore domestic students' social preferences at the beginning of their first year at the university. Figure 4 plots histograms of responses of newly admitted domestic students to two social preference questions. Figure 4a illustrates the expectations of domestic students regarding interacting with foreign students. 80% of the domestic students are looking forward to or very excited to meet foreign students, and 10% of the domestic students have not thought about it. Figure 4b summarizes their opinions on whether immigrants contribute to cultural enrichment in a country. Over 90% of the students agree that immigrants enrich a country culturally. Both these statistics show no signs of social preference against interacting with foreign students — most students feel excited about the possibility of interacting with foreign students and hold a positive belief about immigrants.

I further explore the social preference channel using the administrative data. I estimate the effect of domestic Asian students on domestic students of all other races. Domestic Asian students are likely to have more shared interests (for instance, American football) with other domestic students but are similar in appearance to foreign students, who are primarily Asians. Also, communication in English would not be a barrier for them. If social preference over race is a potential mechanism, one should expect domestic Asian students to have a negative impact on other domestic students too. For this analysis, I focus on the main sample students, excluding the Asian students, and use a specification similar to the main specification 1, replacing the main treatment variable with the share of domestic Asian students in the peer group. Appendix Table A.6 reports the results of this analysis. The impact of domestic Asian students on other domestic students is not statistically significant at any conventional level (p-value = 0.4). Overall, I do not find any evidence that social preferences of domestic students over race, foreign students, or immigrants are likely mechanisms through which peer effects are operating.

Next, we look at the actual interactions of domestic students with foreign students during their first year. Using data from the follow-up survey conducted at the beginning of students' second year at the university, Figure 5 plots histograms of the number of interactions domestic students had with foreign students in their first year in different settings and the number of friends they met who are foreigners. Close to 50% of the domestic students interacted less than three times with any foreign student in their first year in formal settings (Figure 5a). Another 30% of domestic students only interacted sometimes in an entire academic year in formal settings. The histogram on the number of interactions in social settings also tells the same story (Figure 5b). Figure 5c provides additional evidence on the interaction of domestic with foreign students. Roughly 70% of domestic students had no friends from foreign countries among the five closest they met in the first year at the university, and an additional 17% had one foreign friend among the five closest ones. These statistics show that even though most domestic students are looking forward or excited to interact with foreign students, their actual interaction is very limited, which may very well affect collaboration or the classroom environment, in turn leading to negative peer effects.[24]

Why do domestic students have limited interaction with foreign students? The follow-up

[24] Due to small sample size, I can not explore interaction patterns by race, but papers in the literature find strong-race attraction in the determination of social networks among university students (Marmaros and Sacerdote, 2006; Mayer and Puller, 2008).

survey provides two primary reasons why domestic students fail to form friendships with foreign students. The first reason is the lack of common interests; 44% of them think that "international students have different interests that are not the same as mine." While the survey data suggests the potential role of a lack of common interests between domestic and foreign students, additional research is required to provide rigorous evidence.

The second reason is the language barrier; 60% of domestic students think "communication is difficult because of language." Foreign students may have limited English communication skills as most of them are non-native English speakers, which may lead to limited interaction between domestic and foreign students. In this case, the negative peer effects should be stronger in peer groups with a higher share of foreign peers with lower English ability.

To explore the communication mechanism, I look at the effect of the share of foreign students with high and low English proficiencies within the peer group. In particular, I split the main explanatory variable into two: the share of foreign students with high English proficiency and the share of foreign students with low English ability within a peer group. To measure English proficiency, I use scores from different English language proficiency tests that foreign students take for admission into the university. The scores come from seven different tests: TOEFL internet-based, TOEFL paper-based, TOEFL computer-based, IELTS, SAT, ACT, and University English Language Test. The minimum score required for regular admission is 6.5 on IELTS (or a 79 on TOEFL internet-based). There is a corresponding score for each of the other tests to get regular admission. Since IELTS scores are the crudest, I use that to create a cutoff for the high and low English proficiencies. I take the cutoff to be 7 to create the two categories. Given the cutoff, 23% of foreign peers in lower-ability courses and 16.3% of foreign peers in higher-ability courses have high English proficiency. I rerun the main equation 1, replacing the treatment variable with the two share variables, and report the results in Table 13, Panel A.[25]

I find that the negative effect on graduation is largely due to the exposure to low English proficiency foreign students in lower-ability courses. The estimates imply that a 10 percent-

[25] Appendix Figure A.2 shows the variation in exposure to foreign peers with high/low English proficiency for every student in the main sample.

age point increase in the share of low English proficiency foreign students in the peer group reduces the domestic students' graduation rate by 6.8 percentage points, which is statistically significant at the 1% level. The effect of exposure to high English proficiency foreign students is not significant at any conventional level in lower-ability courses. In a sensitivity analysis of the cutoff, I conduct the same exercise with the cutoff for high English proficiency being 7.5 and report the results in Table 13, Panel B. Results tell the same story. One point to note here is that the presence of low English proficiency foreign students in peer groups can lead to negative peer effects not only through limited interaction between foreign and domestic students but also through how instructors respond to this. For instance, instructors may adjust their pace or style of instruction due to the presence of low English proficiency students, which may lead to negative effects on domestic students.

In summary, the results in this subsection provide suggestive evidence of the presence of non-ability-based mechanisms that may drive the main results. While I find evidence of limited interaction, lack of common interests, and language barrier between domestic and foreign students that may affect collaboration or classroom dynamics, among other factors contributing to peer effects, further research is required to provide more conclusive evidence.

VIII. Conclusion

In this paper, I estimate how exposure to foreign peers in college courses affects domestic students' academic outcomes. I use rich administrative and survey data from a large US public university to provide evidence on the peer effects of foreign students. On average, exposure to foreign peers leads to a sizable negative effect on domestic students' graduation rate in lower-ability courses; there is no effect on domestic students in higher-ability courses. Of the students who do not graduate due to exposure to foreign peers, roughly 70% of them drop out in the first year. Further, students of all races except Asians incur negative peer effects; Asian students incur positive peer effects. The decline in graduation comes through a drop in students graduating with non-STEM degrees, with no effect on the number of STEM graduates. In fact, exposure to a higher share of foreign students in higher-ability courses reduces the likelihood that domestic students move out of STEM majors.

I test several mechanisms to explore why foreign peers negatively affect domestic students' graduation rate in lower-ability courses. First, I find a negative effect on the short-term achievement of domestic students, which may negatively affect graduation. Also, one-third of the effect on graduation may be due to an effect on the academic rank of students. Second, I do not find evidence in support of the ability channel — differences in the abilities of foreign and domestic students may not be driving the results. Third, while I do not find evidence of domestic students' social preferences against interacting with foreign students, there is very limited interaction between students of the two groups. Two major reasons domestic students mention that hinder their interaction with foreign students are a lack of common interests and communication due to the language barrier. Further, I find that negative peer effects are largely driven by the presence of foreign peers with low English proficiency, providing additional evidence on the potential role of the communication mechanism.

My findings are also of relevance to policymakers and university administrators. As noted earlier, the number of foreign students in post-secondary education has grown drastically in the last few decades around the world and in the US. The US colleges and universities also saw this as an opportunity to recruit global talent in addition to generating higher revenue. The number of foreign students is expected to grow further, especially from emerging economies (such as China and India) where the average earnings are increasing and more families are able to afford high-quality education in developed countries. At a time when the enrollment of domestic students is declining, US universities may become even more dependent on tuition revenue from foreign students. While we must be cautious in extrapolating from one university to other universities in the US and around the world, my findings show that there are negative effects on academic outcomes, which may not be driven by differences in abilities. At the same time, there may not be benefits of desegregation on social preferences due to limited interaction between the two groups. Universities may consider taking more proactive measures to encourage interaction, engagement, and collaboration between the two groups to harness the potential benefits of diversity on academic and social outcomes. ■

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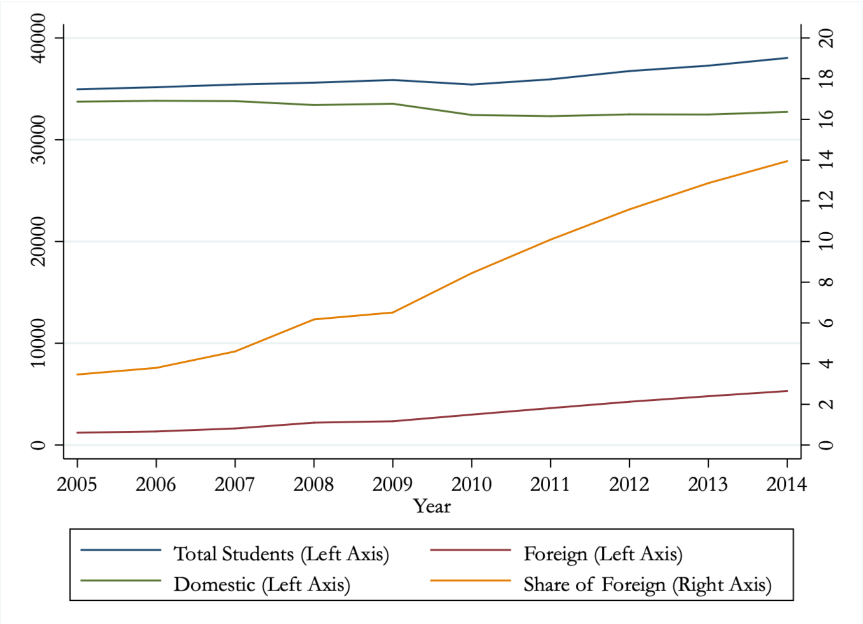
Main Tables and Figures

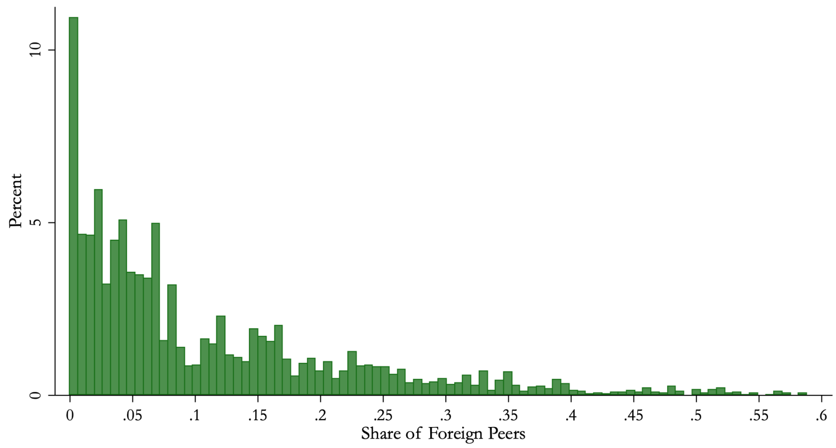
Figure 1: FOREIGN STUDENT ENROLLMENT TREND AT THE UNIVERSITY



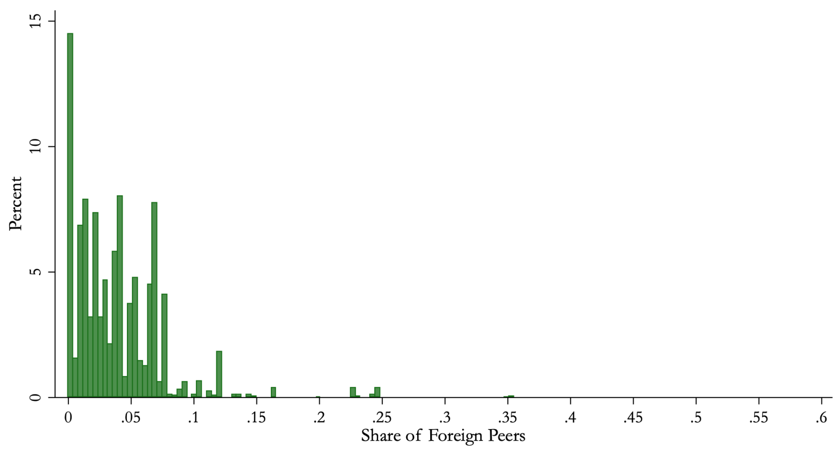
Notes: The figure shows the student enrollment trend at the university between 2005 and 2014. The blue line indicates the enrollment trend for total undergraduate student enrollment. The red and green lines indicate the foreign and domestic undergraduate student enrollment trends, respectively. The yellow line indicates the trend of the share of foreign students among the total undergraduate student enrollment. Source: Authors' calculation using data from the university.

Figure 2: DISTRIBUTION OF SHARE OF FOREIGN PEERS

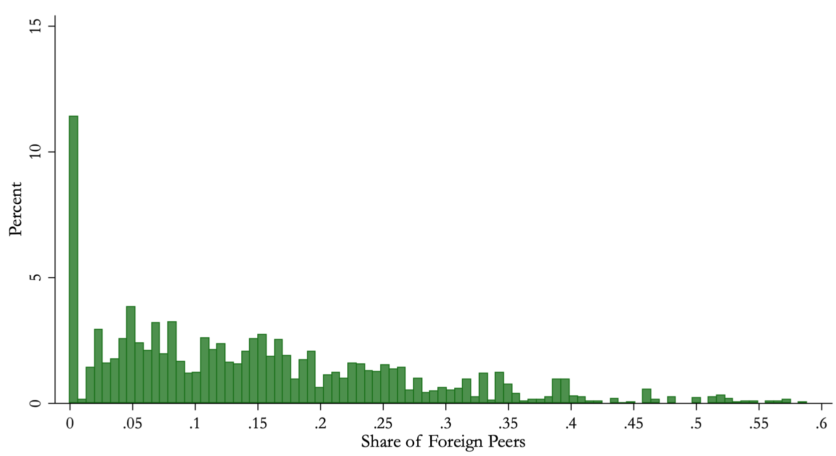
(a) ALL COURSES



(b) LOW-ABILITY COURSES

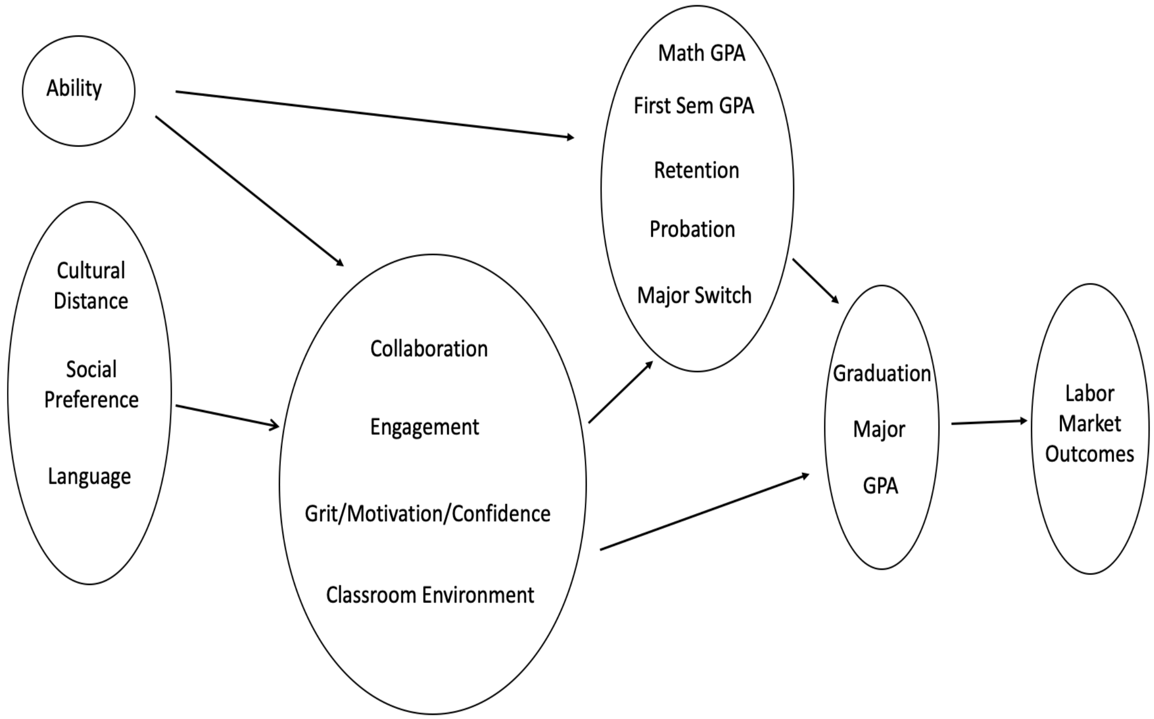


(c) HIGH-ABILITY COURSES



Notes: This figure shows the distribution of exposure to foreign peers (proxied by the share of foreign students in the peer group) for students in the main sample. Source: Authors' calculation using university administrative data.

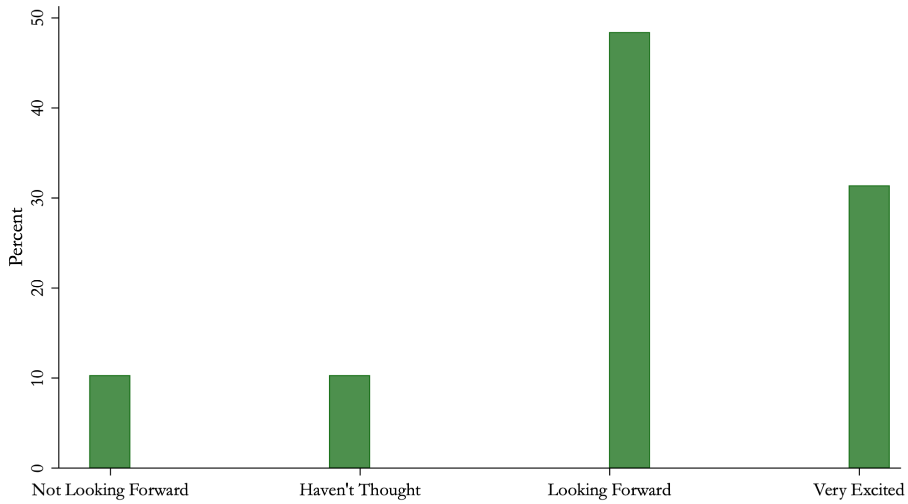
Figure 3: Stylized Overview of Possible Channels



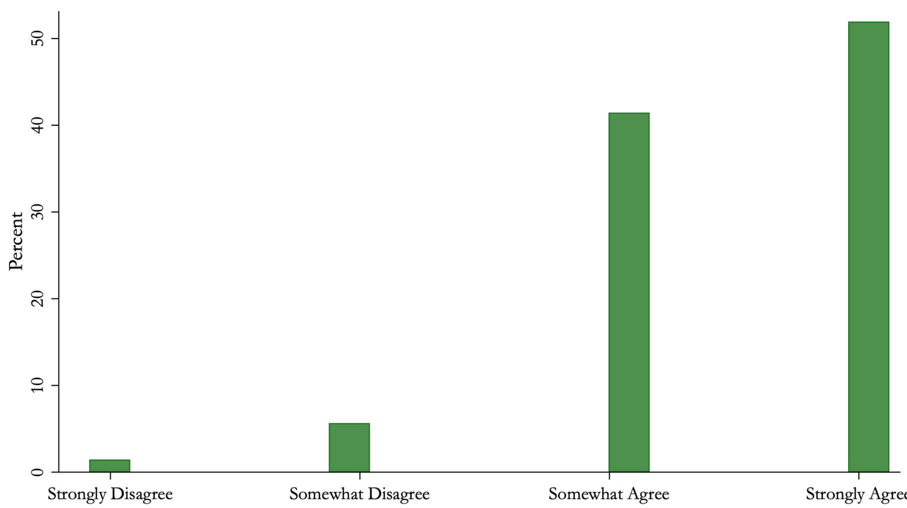
Notes: Overview of the potential channels through which the peer effects might operate.

Figure 4: Social Preference of Domestic Students

(a) Expectations to Meet Foreign Students



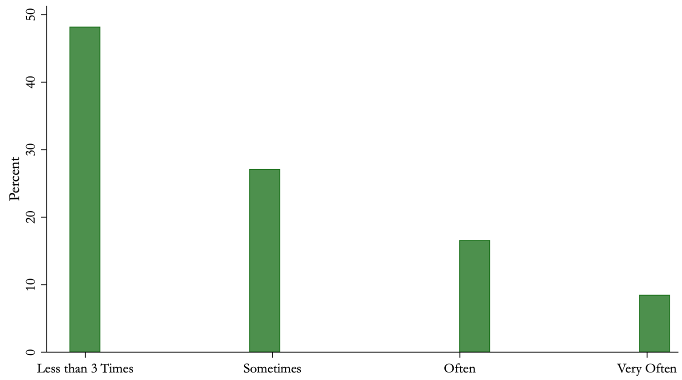
(b) Immigrants Enrich a Country Culturally



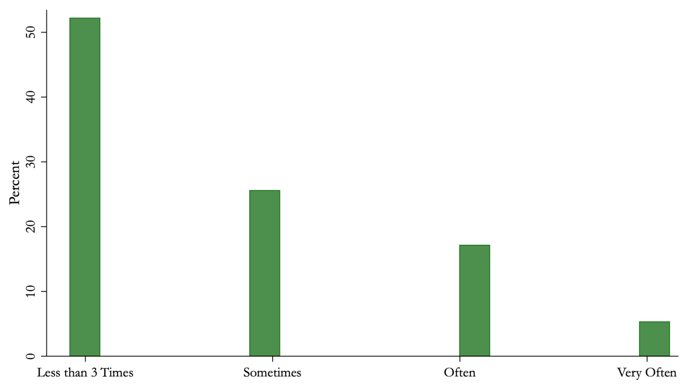
Notes: This figure displays students' responses to social preference questions in the baseline survey. Figure 4a displays the summary of the responses to the question on students' expectations to interact with foreign students during their time at the university. Figure 4b displays the summary of the responses to the question about whether the student believes that immigrants enrich a country culturally. Sample: First-time freshman domestic students in Fall 2018 at the university. Source: Authors' calculation using survey data.

Figure 5: ACTUAL INTERACTION OF DOMESTIC STUDENTS IN THE FIRST YEAR

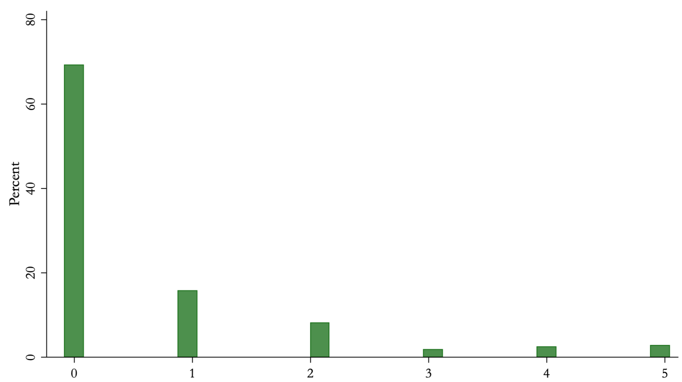
(a) INTERACTION IN FORMAL SETTINGS



(b) INTERACTION IN SOCIAL SETTINGS



(c) NUMBER OF FOREIGN STUDENTS AMONG FIVE CLOSEST FRIENDS YOU MET IN THE FIRST YEAR



Notes: This figure displays domestic students' responses to questions on actual interactions with foreign students in their first year. Figure 5a displays the summary of the domestic student's number of interactions with foreign students in formal settings during their first year at the university. Figure 5b displays the summary of the domestic student's number of interactions with foreign students in social settings during their first year at the university. Figure 5c displays the summary of the domestic student's number of friends who are foreign students among the five closest friends they met in the first year at the university. Sample: First-time freshman domestic students in Fall 2018 at the university. Source: Authors' calculation using survey data.

Table 1: SUMMARY STATISTICS

	Lower Ability	Higher Ability	Total
PANEL A: MAIN SAMPLE			
White	0.836	0.848	0.841
	(0.370)	(0.360)	(0.366)
Black	0.061	0.020	0.043
	(0.239)	(0.139)	(0.203)
Asian	0.029	0.071	0.047
	(0.167)	(0.257)	(0.211)
Hispanic	0.039	0.024	0.033
	(0.194)	(0.153)	(0.178)
Female	0.563	0.338	0.468
	(0.496)	(0.473)	(0.499)
First Gen	0.184	0.135	0.163
	(0.387)	(0.342)	(0.369)
Math	23.856	27.970	25.588
	(2.494)	(3.041)	(3.409)
English	24.371	26.326	25.206
	(3.747)	(4.002)	(3.977)
Foreign Share	0.039	0.150	0.086
	(0.036)	(0.127)	(0.103)
Observations	18495	13620	32115
PANEL B: FOREIGN PEERS			
China	0.470	0.714	0.675
	(0.499)	(0.452)	(0.468)
Korea	0.141	0.096	0.103
	(0.348)	(0.294)	(0.304)
Taiwan	0.043	0.027	0.029
	(0.203)	(0.161)	(0.169)
India	0.049	0.024	0.028
	(0.215)	(0.152)	(0.164)
Saudi Arabia	0.052	0.026	0.030
	(0.223)	(0.158)	(0.170)
Female	0.352	0.352	0.352
	(0.478)	(0.478)	(0.478)
First Gen	0.205	0.200	0.201
	(0.404)	(0.400)	(0.401)
Math	25.922	28.803	28.327
	(3.235)	(2.336)	(2.725)
Observations	1072	5683	6755

Notes: Panel A in the table shows the summary statistics (mean) for demographic characteristics, academic ability, and share of foreign peers for the main student sample. Panel B shows the summary statistics (mean) for demographic characteristics (including home country) and academic ability of foreign peers of the main sample students. Each column corresponds to the sample used for the analysis and is denoted in the column header. Lower Ability denotes the sample of students enrolled in introductory non-calculus courses. Higher Ability denotes the sample of students enrolled in introductory calculus-based courses. Sample: First-time freshman domestic students and their foreign peers enrolled in introductory math courses in their first term between 2005-2014. Source: Authors' calculation using university administrative data.

Table 2: BALANCE TEST: MAIN SAMPLE

	White	Black	Asian	Hispanic	Other Minority	Female	First Gen	Math	English
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
PANEL A: WITHOUT FIXED EFFECTS									
Foreign Share	-0.007***	-0.009***	0.014***	-0.001	0.004***	-0.058***	0.012***	1.124***	0.711***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.002)	(0.019)	(0.023)
Mean Dep. Var.	0.84	0.04	0.05	0.03	0.04	0.47	0.16	25.59	25.21
N	32115	32115	32115	32115	32115	32115	32115	31919	29263
PANEL B: WITH FIXED EFFECTS									
Foreign Share	-0.002	-0.003	0.005	-0.002	0.002	-0.001	-0.002	0.053	0.046
	(0.006)	(0.003)	(0.004)	(0.003)	(0.003)	(0.007)	(0.006)	(0.044)	(0.060)
Mean Dep. Var.	0.84	0.04	0.05	0.03	0.04	0.47	0.16	25.59	25.21
N	32099	32099	32099	32099	32099	32099	32099	31903	29246

Notes: This table shows the results from the balance test using the main sample. Each column corresponds to a separate regression of students' pre-determined demographic and academic characteristics on exposure to foreign peers (proxied by the share of foreign students in the peer group), with outcome variables denoted by the column headers. In Panel A, the regressions do not control for any additional variables. In Panel B, all regressions control for course-instructor FEs and course-term FEs. Robust standard errors clustered at instructor level in parenthesis. Sample: First-time freshman domestic students enrolled in introductory math courses in their first term between 2005-2014. Source: Authors' calculation using university administrative data. Significance: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table 3: BALANCE TEST: FOREIGN PEERS

	China	Korea	Taiwan	India	Saudi Arabia	Female	First Gen	Math
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PANEL A: MAIN SAMPLE EQUIVALENT								
Foreign Share	0.009	0.001	0.004	-0.001	-0.003	-0.011	-0.000	0.022
	(0.009)	(0.005)	(0.003)	(0.002)	(0.003)	(0.012)	(0.012)	(0.049)
Mean Dep. Var.	0.71	0.09	0.03	0.03	0.02	0.40	0.22	28.57
N	3622	3622	3622	3622	3622	3622	3622	3370
PANEL B: OTHER FOREIGN STUDENTS								
Foreign Share	0.035	0.026	-0.008	-0.012	-0.002	0.039*	0.020	0.246*
	(0.026)	(0.018)	(0.006)	(0.010)	(0.006)	(0.021)	(0.016)	(0.127)
Mean Dep. Var.	0.63	0.11	0.02	0.03	0.04	0.30	0.18	28.03
N	2918	2918	2918	2918	2918	2918	2918	2719

Notes: This table shows the results from the balance test using the sample of foreign peers. Panel A reports the results for the sample of first-time freshman foreign peers who enrolled in introductory math courses in their first term between 2005-2014. Panels B reports the results for all the other foreign peers who enrolled in introductory math courses between 2005-2014. Each column corresponds to a separate regression of students' pre-determined demographic and academic characteristics on exposure to foreign peers (proxied by the share of foreign students in the peer group), with outcome variables denoted by the column headers. All regressions control for course-instructor FEs and course-term FEs. Robust standard errors clustered at instructor level in parenthesis. Sample: Foreign peers of first-time freshman domestic students enrolled in introductory math courses in their first term between 2005-2014. Source: Authors' calculation using university administrative data. Significance: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table 4: COMPARING SPECIFICATIONS

	Graduation in 6 Years					
	(1)	(2)	(3)	(4)	(5)	(6)
PANEL A: WITHOUT FIXED EFFECTS						
Foreign Share	0.013***	0.014***	0.008***	0.008***	0.002	-0.000
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Mean Dep. Var.	0.79	0.79	0.80	0.80	0.80	0.80
N	32115	32115	29263	29263	29263	29263
R-squared	0.00	0.02	0.02	0.02	0.02	0.02
PANEL B: WITH FIXED EFFECTS						
Foreign Share	-0.011*	-0.011*	-0.010	-0.009	-0.010	-0.011*
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Mean Dep. Var.	0.79	0.79	0.80	0.80	0.80	0.80
N	32099	32099	29246	29246	29246	29246
R-squared	0.03	0.04	0.05	0.05	0.05	0.05
Ind. Char		✓	✓	✓	✓	✓
Ind. Ability			✓	✓	✓	✓
Peer Group Size				✓	✓	✓
Peer Char.					✓	✓
Peer Ability						✓

Notes: This table reports the results of regression using various versions of the main equation. Each column corresponds to a separate regression of "six-year graduation" on exposure to foreign peers (proxied by the share of foreign students in the peer group). In Panel A, the regressions do not include fixed effects. In Panel B, all regressions include course-instructor FEs and course-term FEs. Moving from column 1 to column 6, controls are sequentially included. Individual characteristics controls include race dummies, a female indicator, and a first-generation indicator. Individual ability controls include math and English ability. Peer characteristics controls include the shares of female students and first-generation students in the peer group. Peer ability control includes the mean math ability of the students in the peer group. Robust standard errors clustered at instructor level in parenthesis. Sample: First-time freshman domestic students enrolled in introductory math courses in their first term between 2005-2014. Source: Authors' calculation using university administrative data. Significance: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table 5: MAIN RESULT: IMPACT ON GRADUATION

	Graduation in 6 Years		
	(1) Full Sample	(2) Lower Ability	(3) Higher Ability
Foreign Share	-0.011*	-0.061***	-0.007
	(0.006)	(0.020)	(0.007)
Mean Dep. Var.	0.80	0.78	0.83
N	29246	16771	12475
R-squared	0.05	0.04	0.06

Notes: This table reports the effect of exposure to foreign peers (proxied by share of foreign students in the peer group) on domestic students' six-year graduation rate. Each column corresponds to the sample used for the analysis and is denoted in the column header. Lower Ability denotes the sample of students enrolled in introductory non-calculus courses. Higher Ability denotes the sample of students enrolled in introductory calculus-based courses. All regressions control for course-instructor FEs, course-term FEs, students' own characteristics (race, gender, first-generation flag), students' own math and English ability, peer group size, peer characteristics (share of female students, share of first-generation students), and peer math ability (average math ability). Robust standard errors clustered at instructor level in parenthesis. Sample: First-time freshman domestic students enrolled in introductory math courses in their first term between 2005-2014. Source: Authors' calculation using university administrative data. Significance: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table 6: ROBUSTNESS

	Baseline	Class-Level Controls	Freshman Major FEs	Only College Algebra	Foreign Math	AM/PM Control	Class-Level Variation
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
PANEL A: LOWER ABILITY							
Foreign Share	-0.061***	-0.062***	-0.064***	-0.073***	-0.057**	-0.058***	
	(0.020)	(0.020)	(0.020)	(0.021)	(0.029)	(0.021)	
Class Foreign Share							-0.065***
							(0.021)
Mean Dep. Var.	0.78	0.78	0.78	0.79	0.78	0.78	0.78
First Stage F-stat							797
N	16771	16771	16681	10757	14334	16771	16771
R-squared	0.04	0.04	0.07	0.05	0.04	0.04	0.02
PANEL B: HIGHER ABILITY							
Foreign Share	-0.007	-0.007	-0.009		-0.008	-0.007	
	(0.007)	(0.007)	(0.007)		(0.007)	(0.007)	
Class Foreign Share							-0.007
							(0.007)
Mean Dep. Var.	0.83	0.83	0.83		0.83	0.83	0.83
First Stage F-stat							2211
N	12475	12475	11987		10817	12475	12475
R-squared	0.06	0.06	0.08		0.06	0.06	0.01

Notes: This table reports the effect of exposure to foreign peers (proxied by share of foreign students in the peer group) on domestic students' six-year graduation rate. Each panel corresponds to the sample used for the analysis. Lower Ability denotes the sample of students enrolled in introductory non-calculus courses. Higher Ability denotes the sample of students enrolled in introductory calculus-based courses. Each column corresponds to a separate robustness test of the main result, denoted in the column header. Column 1 replicates the main result using the main equation 1. Column 2 additionally controls for the class-level characteristics (class size, shares of female students, share of first-generation students, and average math ability). Column 3 additionally controls for freshman major preference fixed effects. Column 4 restricts the sample to the most basic course, College Algebra. Column 5 separately controls for the average ability of foreign and domestic students in the peer group instead of the average ability of all students in the peer group. Column 6 controls for the morning (before noon) class session dummy. Column 7 estimates the effect of exposure to foreign peers at the class level instead of at the peer group level using equation 1. I instrument for the share of foreign peers at the class level with the share of foreign peers at the peer group level. Sample: First-time freshman domestic students enrolled in introductory math courses in their first term between 2005-2014. Source: Authors' calculation using university administrative data. Significance: *p < 0.10, **p < 0.05, ***p < 0.01.

Table 7: IMPACT ON STEM/NON-STEM MAJOR GRADUATION

	Lower Ability		Higher Ability	
	(1) STEM Graduation	(2) Non-STEM Graduation	(3) STEM Graduation	(4) Non-STEM Graduation
Foreign Share	0.015	-0.078**	0.002	-0.009
	(0.035)	(0.039)	(0.007)	(0.008)
Mean Dep. Var.	0.29	0.50	0.47	0.37
N	16771	16771	12475	12475
R-squared	0.11	0.11	0.18	0.20

Notes: This table reports the effect of exposure to foreign peers (proxied by the share of foreign students in the peer group) on domestic students' major choice outcomes - six-year graduation with a STEM major and six-year graduation with a Non-STEM major. Each column group corresponds to the sample used for the analysis and is denoted in the column group header. Lower Ability denotes the sample of students enrolled in introductory non-calculus courses. Higher Ability denotes the sample of students enrolled in introductory calculus-based courses. Each column corresponds to a separate regression of students' outcomes on exposure to foreign peers, with outcome variables denoted by the column headers. All regressions control for course-instructor FEs, course-term FEs, students' own characteristics (race, gender, first-generation flag), students' own math and English ability, peer group size, peer characteristics (share of female students, share of first-generation students), and peer math ability (average math ability). Robust standard errors clustered at instructor level in parenthesis. Sample: First-time freshman domestic students enrolled in introductory math courses in their first term between 2005-2014. Source: Authors' calculation using university administrative data. Significance: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table 8: IMPACT ON STEM/NON-STEM MAJOR SWITCHING

	Lower Ability			Higher Ability		
	(1) STEM to Non-STEM	(2) Non-STEM to STEM	(3) Exploratory to STEM	(4) STEM to Non-STEM	(5) Non-STEM to STEM	(6) Exploratory to STEM
Foreign Share	-0.026	0.011	0.163	-0.014**	-0.018***	0.017
	(0.076)	(0.020)	(0.138)	(0.007)	(0.007)	(0.034)
Mean Dep. Var.	0.21	0.08	0.28	0.11	0.09	0.53
N	5058	7369	950	5624	3784	981
R-squared	0.07	0.04	0.18	0.11	0.12	0.46

Notes: This table reports the effect of exposure to foreign peers (proxied by the share of foreign students in the peer group) on domestic students' major switching outcomes - starting with a STEM preference but graduating with a Non-STEM major in six years, starting with a Non-STEM preference but graduating with a STEM major in six years, and starting with an Exploratory preference but graduating with a STEM major in six years. Each column group corresponds to the sample used for the analysis and is denoted in the column group header. Lower Ability denotes the sample of students enrolled in introductory non-calculus courses. Higher Ability denotes the sample of students enrolled in introductory calculus-based courses. Each column corresponds to a separate regression of students' outcomes on exposure to foreign peers, with outcome variables denoted by the column headers. All regressions control for course-instructor FEs, course-term FEs, students' own characteristics (race, gender, first-generation flag), students' own math and English ability, peer group size, peer characteristics (share of female students, share of first-generation students), and peer math ability (average math ability). Robust standard errors clustered at instructor level in parenthesis. Sample: First-time freshman domestic students enrolled in introductory math courses in their first term between 2005-2014 and graduated within six years. Source: Authors' calculation using university administrative data. Significance: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table 9: HETEROGENEITY WITH PRE-DETERMINED CHARACTERISTICS

	Graduation in 6 years	
	(1) Lower Ability	(2) Higher Ability
PANEL A: MATH ABILITY		
Foreign Share	-0.061***	-0.007
	(0.020)	(0.007)
Foreign Share * Math	0.005	0.000
	(0.009)	(0.003)
PANEL B: RACE		
Foreign Share	-0.064***	-0.007
	(0.021)	(0.007)
Foreign Share * Black	0.003	-0.027
	(0.055)	(0.033)
Foreign Share * Asian	0.184***	0.002
	(0.056)	(0.011)
Foreign Share * Hispanic	0.040	0.027
	(0.050)	(0.019)
Foreign Share * Other Minority	-0.024	-0.015
	(0.046)	(0.015)
PANEL C: FRESHMAN MAJOR PREFERENCE		
Foreign Share	-0.065***	0.000
	(0.021)	(0.007)
Foreign Share * STEM Preference	0.021	-0.011
	(0.020)	(0.007)
Foreign Share * Exploratory Preference	-0.053*	-0.016
	(0.028)	(0.011)
Mean Dep. Var.	0.78	0.83
N	16771	12475
R-squared	0.04	0.06

Notes: This table reports the heterogeneous effect of exposure to foreign peers (proxied by share of foreign students in the peer group) by domestic students' pre-determined characteristics on their six-year graduation rate. The panel header denotes the characteristics. Each column corresponds to the sample used for the analysis and is denoted in the column header. Lower Ability denotes the sample of students enrolled in introductory non-calculus courses. Higher Ability denotes the sample of students enrolled in introductory calculus-based courses. In Panel A, the student's own math ability is standardized among the sample of students within a course type, and regressions include the interaction term of own math ability and the foreign share. In Panel B, regressions include interaction terms of race dummies and the foreign share, keeping White as the omitted group. In Panel C, the regressions include major preference dummies and their interaction with the foreign share, keeping Non-STEM preference as the omitted group. All regressions further control for course-instructor FEs, course-term FEs, students' own characteristics (race, gender, first-generation flag), students' own math and English ability, peer group size, peer characteristics (share of female students, share of first-generation students), and peer math ability (average math ability). Robust standard errors clustered at instructor level in parenthesis. Sample: First-time freshman domestic students enrolled in introductory math courses in their first term between 2005-2014. Source: Authors' calculation using university administrative data. Significance: *p < 0.10, **p < 0.05, ***p < 0.01.

Table 10: SHORT-RUN OUTCOMES

	Lower Ability			Higher Ability		
	(1) Math Course GPA	(2) First Semester GPA	(3) Retention	(4) Math Course GPA	(5) First Semester GPA	(6) Retention
Foreign Share	-0.159*	-0.085**	-0.044**	0.018	0.007	-0.006*
	(0.094)	(0.033)	(0.018)	(0.019)	(0.011)	(0.004)
Mean Dep. Var.	2.64	3.03	0.89	2.93	3.27	0.93
N	16769	16767	16771	12468	12474	12475
R-squared	0.14	0.09	0.02	0.16	0.11	0.05

Notes: This table reports the effect of exposure to foreign peers (proxied by the share of foreign students in the peer group) on domestic students' short-run academic outcomes - introductory math course GPA, first semester GPA, and retention. Each column group corresponds to the sample used for the analysis and is denoted in the column group header. Lower Ability denotes the sample of students enrolled in introductory non-calculus courses. Higher Ability denotes the sample of students enrolled in introductory calculus-based courses. Each column corresponds to a separate regression of students' outcomes on exposure to foreign peers, with outcome variables denoted by the column headers. All regressions control for course-instructor FEs, course-term FEs, students' own characteristics (race, gender, first-generation flag), students' own math and English ability, peer group size, peer characteristics (share of female students, share of first-generation students), and peer math ability (average math ability). Robust standard errors clustered at instructor level in parenthesis. Sample: First-time freshman domestic students enrolled in introductory math courses in their first term between 2005-2014. Source: Authors' calculation using university administrative data. Significance: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table 11: EFFECT ON GRADUATION AND RETENTION CONTROLLING FOR SHORT-RUN GRADES

	Lower Ability		Higher Ability	
	(1) Graduation in 6 years	(2) Retention	(3) Graduation in 6 years	(4) Retention
Foreign Share	-0.040*	-0.030*	-0.009	-0.007*
	(0.023)	(0.016)	(0.006)	(0.004)
Short-Term Grades	✓	✓	✓	✓
Mean Dep. Var.	0.78	0.89	0.83	0.93
N	16765	16765	12468	12468
R-squared	0.17	0.14	0.17	0.13

Notes: This table reports the effect of exposure to foreign peers (proxied by the share of foreign students in the peer group) on domestic students' six-year graduation rate and retention. Each column group corresponds to the sample used for the analysis and is denoted in the column group header. Lower Ability denotes the sample of students enrolled in introductory non-calculus courses. Higher Ability denotes the sample of students enrolled in introductory calculus-based courses. Each column corresponds to a separate regression of students' outcomes on exposure to foreign peers, with outcome variables denoted by the column headers. All regressions control for course-instructor FEs, course-term FEs, students' own characteristics (race, gender, first-generation flag), students' own math and English ability, peer group size, peer characteristics (share of female students, share of first-generation students), and peer math ability (average math ability). Regressions also control for students' own introductory math course GPA and first-semester GPA. Robust standard errors clustered at instructor level in parenthesis. Sample: First-time freshman domestic students enrolled in introductory math courses in their first term between 2005-2014. Source: Authors' calculation using university administrative data. Significance: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table 12: Ability-Based Mechanism

	Lower Ability		Higher Ability	
	(1) Graduation in 6 Years	(2) Graduation in 6 Years	(3) Graduation in 6 Years	(4) Graduation in 6 Years
Foreign Share	-0.061***	-0.054*	-0.006	-0.003
	(0.020)	(0.028)	(0.007)	(0.009)
Foreign Share * Ability Quintile 4		-0.012		0.005
		(0.032)		(0.008)
Foreign Share * Ability Quintile 3		-0.003		-0.009
		(0.036)		(0.009)
Foreign Share * Ability Quintile 2		-0.010		-0.009
		(0.033)		(0.009)
Foreign Share * Ability Quintile 1 (Lowest)		-0.010		-0.001
		(0.031)		(0.009)
Mean Dep. Var.	0.78	0.78	0.83	0.83
N	16769	16769	12468	12468
R-squared	0.04	0.04	0.06	0.06

Notes: This table reports the results from tests of ability-based mechanism. Each column group corresponds to the sample used for the analysis and is denoted in the column group header. Lower Ability denotes the sample of students enrolled in introductory non-calculus courses. Higher Ability denotes the sample of students enrolled in introductory calculus-based courses. The estimates are from the regression of domestic students' six-year graduation on the shares of foreign peers. All regressions control for course-instructor FEs, course-term FEs, students' own characteristics (race, gender, first-generation flag), students' own math and English ability, peer group size, peer characteristics (share of female students, share of first-generation students), and peer math ability (average math ability). Regressions in columns 1 and 3 include ability-quintile dummies, where quintile 5 (highest) is the omitted group. Regressions in columns 2 and 4 include ability-quintile dummies and their interaction terms with the share of foreign peers, where quintile 5 (highest) is the omitted group. Robust standard errors clustered at instructor level in parenthesis. Sample: First-time freshman domestic students enrolled in introductory math courses in their first term between 2005-2014. Source: Authors' calculation using university administrative data. Significance: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table 13: COMMUNICATION MECHANISM

	Graduation in 6 years	
	(1) Lower Ability	(2) Higher Ability
PANEL A: CUTOFF SCORE = 7		
Foreign Share Low English Proficiency (< 7)	-0.068***	-0.007
	(0.023)	(0.007)
Foreign Share High English Proficiency (>= 7)	-0.030	-0.005
	(0.061)	(0.021)
Mean Dep. Var.	0.78	0.83
N	16771	12475
R-squared	0.04	0.06
PANEL B: CUTOFF SCORE = 7.5		
Foreign Share Low English Proficiency (< 7.5)	-0.066***	-0.007
	(0.021)	(0.007)
Foreign Share High English Proficiency (>= 7.5)	-0.023	-0.011
	(0.078)	(0.029)
Mean Dep. Var.	0.78	0.83
N	16771	12475
R-squared	0.04	0.06

Notes: This table reports the results from tests of communication mechanisms. Each column corresponds to the sample used for the analysis and is denoted in the column header. Lower Ability denotes the sample of students enrolled in introductory non-calculus courses. Higher Ability denotes the sample of students enrolled in introductory calculus-based courses. The estimates are from the regression of domestic students' six-year graduation on the shares of foreign peers with low English proficiency and high English proficiency. In Panel A, the cutoff score for high English proficiency is 7 in IELTS, and in Panel B, the cutoff score for high English proficiency is 7.5 in IELTS. All regressions control for course-instructor FEs, course-term FEs, students' own characteristics (race, gender, first-generation flag), students' own math and English ability, peer group size, peer characteristics (share of female students, share of first-generation students), and peer math ability (average math ability). Robust standard errors clustered at instructor level in parenthesis. Sample: First-time freshman domestic students enrolled in introductory math courses in their first term between 2005-2014. Source: Authors' calculation using university administrative data. Significance: *p < 0.10, **p < 0.05, ***p < 0.01.

APPENDIX

"International Peers in Higher Education and Domestic Students' Outcomes"

A Appendix Tables and Figures

Table A.1: LIST OF INTRODUCTORY MATH COURSES

Introductory Math Courses	Average Number of Students in Course-Instructor-Term Combinations	Total Number of Course-Instructor-Term Combinations
PANEL A: LOWER-ABILITY		
College Algebra	72.68	225
Finite Math and Elements of College Algebra	171.81	16
Trigonometry	84.89	19
College Algebra and Trigonometry	173.41	34
PANEL B: HIGHER-ABILITY		
Survey of Calculus	41.89	336
Calculus 1	32.60	270
Calculus 2	53.88	75
Multivariable Calculus	73.43	61
Differential Equations	76.92	26

Notes: This table shows the list of introductory math courses and their summary statistics. Panel A lists Lower-Ability courses, which include introductory non-calculus courses. Panel B lists Higher-Ability courses, which include introductory calculus-based courses. Sample: Introductory math courses between 2005-2014. Source: Authors' calculation using university administrative data.

Table A.2: BALANCE TEST: PEER GROUP

	Female	First Gen	Math	Peer Group Size
	(1)	(2)	(3)	(4)
PANEL A: WITHOUT FIXED EFFECTS				
Average Foreign Share	-0.021***	0.027***	0.672***	-5.060**
	(0.004)	(0.003)	(0.057)	(2.127)
Mean Dep. Var.	0.39	0.15	25.94	56.50
N	1062	1062	1062	1062
PANEL B: WITH FIXED EFFECTS				
Average Foreign Share	-0.002	-0.007	0.228***	0.242
	(0.005)	(0.005)	(0.042)	(0.761)
Mean Dep. Var.	0.39	0.15	25.94	56.50
N	611	611	611	611

Notes: This table shows the results from the balance test of the peer group. Each column corresponds to a separate regression of peer group level average pre-determined demographic and academic characteristics of students on the share of foreign students in the peer group, with outcome variables denoted by the column headers. In Panel A, the regressions do not control for any additional variables. In Panel B, all regressions control for course-instructor FEs and course-term FEs. Robust standard errors clustered at instructor level in parenthesis. Sample: Introductory math courses between 2005-2014. Source: Authors' calculation using university administrative data. Significance: *p $<$ 0.10, **p $<$ 0.05, ***p $<$ 0.01.

Table A.3: BALANCE TEST: DOMESTIC NON-MAIN SAMPLE

	White	Black	Asian	Hispanic	Other Minority	Female	First Gen	Math	English
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
PANEL A: WITHOUT FIXED EFFECTS									
Foreign Share	0.005	-0.011***	0.003*	0.001	0.003**	-0.042***	0.046***	0.743***	0.583***
	(0.004)	(0.003)	(0.001)	(0.002)	(0.001)	(0.009)	(0.008)	(0.152)	(0.083)
Mean Dep. Var.	0.80	0.08	0.04	0.04	0.04	0.36	0.18	24.23	23.56
N	21138	21138	21138	21138	21138	21138	21138	19932	16786
PANEL B: WITH FIXED EFFECTS									
Foreign Share	-0.002	0.002	-0.001	-0.003	0.004	-0.018**	-0.005	-0.112	-0.074
	(0.007)	(0.004)	(0.004)	(0.004)	(0.003)	(0.008)	(0.007)	(0.070)	(0.089)
Mean Dep. Var.	0.80	0.08	0.04	0.04	0.04	0.36	0.18	24.23	23.56
N	21126	21126	21126	21126	21126	21126	21126	19920	16763

Notes: This table shows the results from the balance test using the domestic peers who are not in the main sample. Each column corresponds to a separate regression of students' pre-determined demographic and academic characteristics on exposure to foreign peers (proxied by the share of foreign students in the peer group), with outcome variables denoted by the column headers. In Panel A, the regressions do not control for any additional variables. In Panel B, all regressions control for course-instructor FEs and course-term FEs. Robust standard errors clustered at instructor level in parenthesis. Sample: Domestic students not in the main sample and are enrolled in introductory math courses between 2005-2014. Source: Authors' calculation using university administrative data. Significance: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table A.4: BALANCE TEST: MAIN SAMPLE (BY COURSE-TYPE)

	White	Black	Asian	Hispanic	Other Minority	Female	First Gen	Math	English
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
PANEL A: LOWER ABILITY									
Foreign Share	0.001	-0.010	-0.005	0.003	0.012	-0.025	-0.009	-0.085	0.149
	(0.028)	(0.020)	(0.009)	(0.010)	(0.015)	(0.026)	(0.026)	(0.173)	(0.266)
Mean Dep. Var.	0.84	0.04	0.05	0.03	0.04	0.47	0.16	25.59	25.21
N	18493	18493	18493	18493	18493	18493	18493	18477	16771
PANEL B: HIGHER ABILITY									
Foreign Share	-0.002	-0.003	0.006	-0.002	0.001	0.000	-0.002	0.062	0.039
	(0.007)	(0.002)	(0.004)	(0.003)	(0.003)	(0.007)	(0.006)	(0.045)	(0.062)
Mean Dep. Var.	0.84	0.04	0.05	0.03	0.04	0.47	0.16	25.59	25.21
N	13606	13606	13606	13606	13606	13606	13606	13426	12475

Notes: This table shows the results from the balance test using the main sample by course type. Each column corresponds to a separate regression of students' pre-determined demographic and academic characteristics on exposure to foreign peers (proxied by the share of foreign students in the peer group), with outcome variables denoted by the column headers. All regressions control for course-instructor FEs and course-term FEs. Each panel corresponds to the sample used for the analysis. Lower Ability denotes the sample of students enrolled in introductory non-calculus courses. Higher Ability denotes the sample of students enrolled in introductory calculus-based courses. Robust standard errors clustered at instructor level in parenthesis. Sample: First-time freshman domestic students enrolled in introductory math courses in their first term between 2005-2014. Source: Authors' calculation using university administrative data. Significance: *p $<$ 0.10, **p $<$ 0.05, ***p $<$ 0.01.

Table A.5: COMPARING SPECIFICATIONS (BY COURSE-TYPE)

	Graduation in 6 Years					
	(1)	(2)	(3)	(4)	(5)	(6)
PANEL A: LOWER ABILITY (WITHOUT FIXED EFFECTS)						
Foreign Share	0.009	0.019*	0.006	-0.001	-0.015*	-0.015*
	(0.009)	(0.010)	(0.009)	(0.009)	(0.008)	(0.008)
Mean Dep. Var.	0.77	0.77	0.78	0.78	0.78	0.78
N	18495	18495	16772	16772	16772	16772
R-squared	0.00	0.02	0.02	0.02	0.02	0.02
PANEL B: LOWER ABILITY (WITH FIXED EFFECTS)						
Foreign Share	-0.055**	-0.056***	-0.062***	-0.059***	-0.064***	-0.061***
	(0.022)	(0.020)	(0.019)	(0.020)	(0.020)	(0.020)
Mean Dep. Var.	0.77	0.77	0.78	0.78	0.78	0.78
N	18493	18493	16771	16771	16771	16771
R-squared	0.02	0.03	0.04	0.04	0.04	0.04
PANEL C: HIGHER ABILITY (WITHOUT FIXED EFFECTS)						
Foreign Share	-0.002	0.000	0.001	0.000	-0.005	-0.005
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Mean Dep. Var.	0.82	0.82	0.83	0.83	0.83	0.83
N	13620	13620	12491	12491	12491	12491
R-squared	0.00	0.01	0.01	0.01	0.01	0.01
PANEL D: HIGHER ABILITY (WITH FIXED EFFECTS)						
Foreign Share	-0.008	-0.008	-0.006	-0.006	-0.006	-0.007
	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)	(0.007)
Mean Dep. Var.	0.82	0.82	0.83	0.83	0.83	0.83
N	13606	13606	12475	12475	12475	12475
R-squared	0.04	0.05	0.06	0.06	0.06	0.06
Ind. Char		✓	✓	✓	✓	✓
Ind. Ability			✓	✓	✓	✓
Peer Group Size				✓	✓	✓
Peer Char.					✓	✓
Peer Ability						✓

Notes: This table reports the results of regression using various versions of the main equation. Each column corresponds to a separate regression of "six-year graduation" on exposure to foreign peers (proxied by the share of foreign students in the peer group). Lower Ability denotes the sample of students enrolled in introductory non-calculus courses. Higher Ability denotes the sample of students enrolled in introductory calculus-based courses. In Panels A and C, the regressions do not include fixed effects. In Panels B and D, all regressions include course-instructor FEs and course-term FEs. Moving from column 1 to column 6, controls are sequentially included. Individual characteristics controls include race dummies, a female indicator, and a first-generation indicator. Individual ability controls include math and English ability. Peer characteristics controls include the shares of female students and first-generation students in the peer group. Peer ability control includes the mean math ability of the students in the peer group. Robust standard errors clustered at instructor level in parenthesis. Sample: First-time freshman domestic students enrolled in introductory math courses in their first term between 2005-2014. Source: Authors' calculation using university administrative data. Significance: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

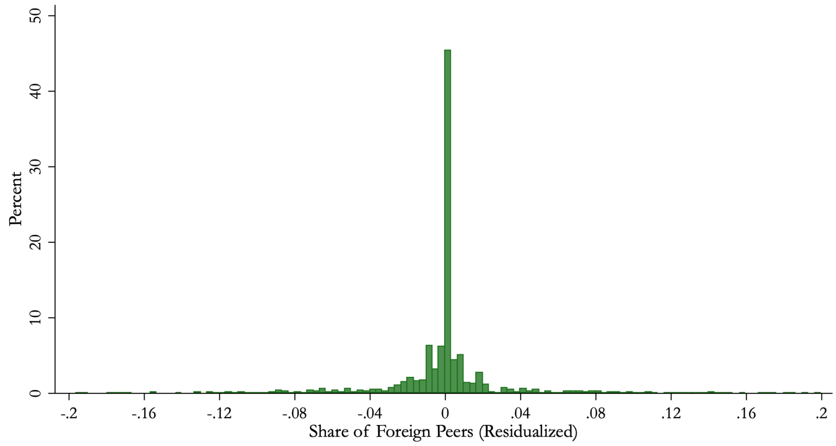
Table A.6: EFFECT OF EXPOSURE TO DOMESTIC ASIAN STUDENTS ON OTHER DOMESTIC STUDENTS

	Graduation in 6 Years	
	(1) Lower Ability	(2) Higher Ability
Domestic Asian Share	-0.030	-0.007
	(0.035)	(0.012)
Mean Dep. Var.	0.78	0.83
N	16310	11653
R-squared	0.04	0.06

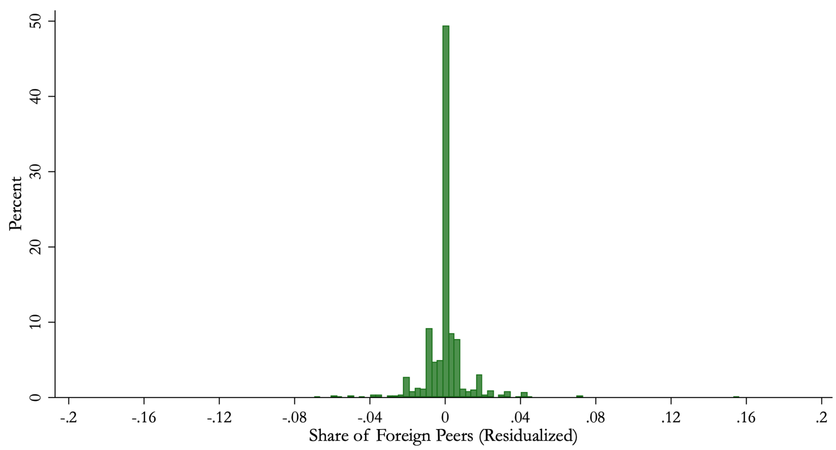
Notes: This table reports the effect of exposure to domestic Asian students (proxied by share of domestic Asian students in the peer group) on Non-Asian domestic students' six-year graduation rate. Each column corresponds to the sample used for the analysis and is denoted in the column header. Lower Ability denotes the sample of Non-Asian domestic students enrolled in introductory non-calculus courses. Higher Ability denotes the sample of Non-Asian domestic students enrolled in introductory calculus-based courses. All regressions control for course-instructor FEs, course-term FEs, students' own characteristics (race, gender, first-generation flag), students' own math and English ability, peer group size, peer characteristics (share of female students, share of first-generation students), and peer math ability (average math ability). Robust standard errors clustered at instructor level in parenthesis. Sample: First-time freshman Non-Asian domestic students enrolled in introductory math courses in their first term between 2005-2014. Source: Authors' calculation using university administrative data. Significance: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Figure A.1: DISTRIBUTION OF SHARE OF FOREIGN PEERS (RESIDUALIZED)

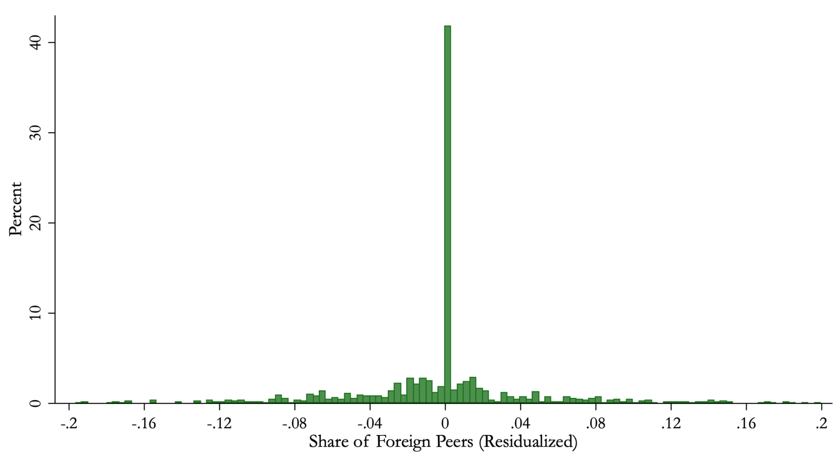
(a) ALL COURSES



(b) LOWER-ABILITY COURSES



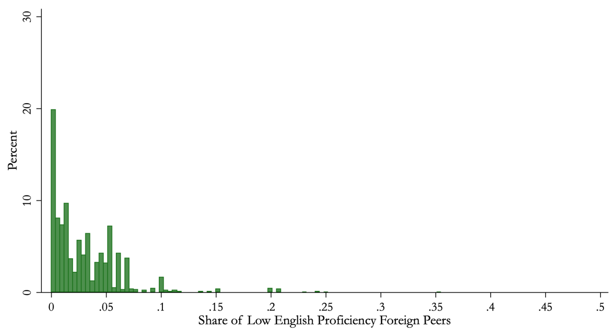
(c) HIGHER-ABILITY COURSES



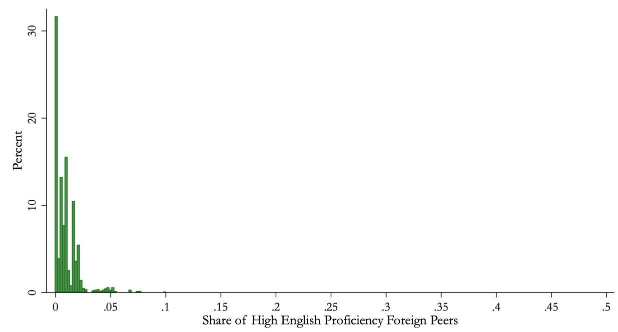
Notes: This figure shows the distribution of residualized exposure to foreign peers (proxied by the share of foreign students in the peer group) for students in the main sample. Source: Authors' calculation using university administrative data.

Figure A.2: DISTRIBUTION OF SHARE OF FOREIGN PEERS WITH HIGH/LOW ENGLISH PROFICIENCY (BY COURSE-TYPE)

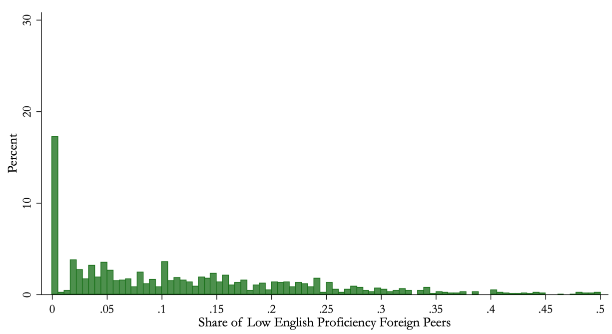
(a) LOWER-ABILITY COURSES: LOW ENGLISH PROFICIENCY FOREIGN PEERS



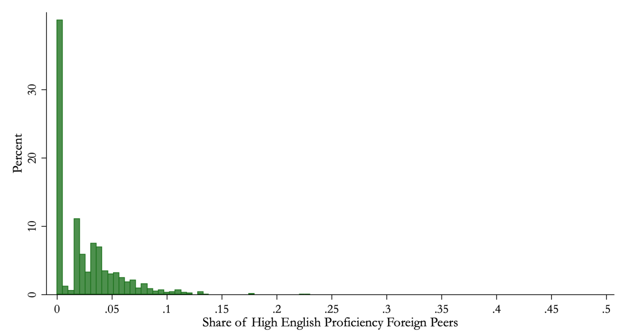
(b) LOWER-ABILITY COURSES: HIGH ENGLISH PROFICIENCY FOREIGN PEERS



(c) HIGHER-ABILITY COURSES: LOW ENGLISH PROFICIENCY FOREIGN PEERS



(d) HIGHER-ABILITY COURSES: HIGH ENGLISH PROFICIENCY FOREIGN PEERS



Notes: This figure shows the distribution of exposure to foreign peers with high/low English proficiency (proxied by the share of foreign students with high/low English proficiency in the peer group) for students in the main sample. Source: Authors' calculation using university administrative data.

B Appendix: Additional Analysis

B.1 Non-Linear Effects

There is substantial variation in the share of foreign peers — Figure B.1 shows the mean exposure to foreign peers corresponding to each of the 5 quintile categories of the distribution of the share of foreign peers. The highest quintile, Q5, corresponds to the highest share of foreign peers, and the lowest quintile, Q1, corresponds to the lowest share of foreign peers. The average share of foreign peers in the first quintile (Q1) is 0.4 %, whereas the average share in the fifth quintile (Q5) is 25.9%. Given the large variation, constraining the effects of exposure to foreign peers to be linear may be too restrictive; its effects might manifest only when the share of foreign peers is above a certain threshold. Further, the distribution of the share of foreign peers is different in the lower-ability courses than in the higher-ability ones (Figure 2), where the share of foreign peers is much higher in higher-ability courses. It might be that exposure to foreign peers influences graduation non-linearly, and that is partly the reason why we observe no effect in higher-ability courses. Thus, to better understand the effects of exposure to foreign peers, I explore the non-linearities in the effect across the quintile categories of the distribution of the share of foreign peers. Specifically, I estimate the following equation:

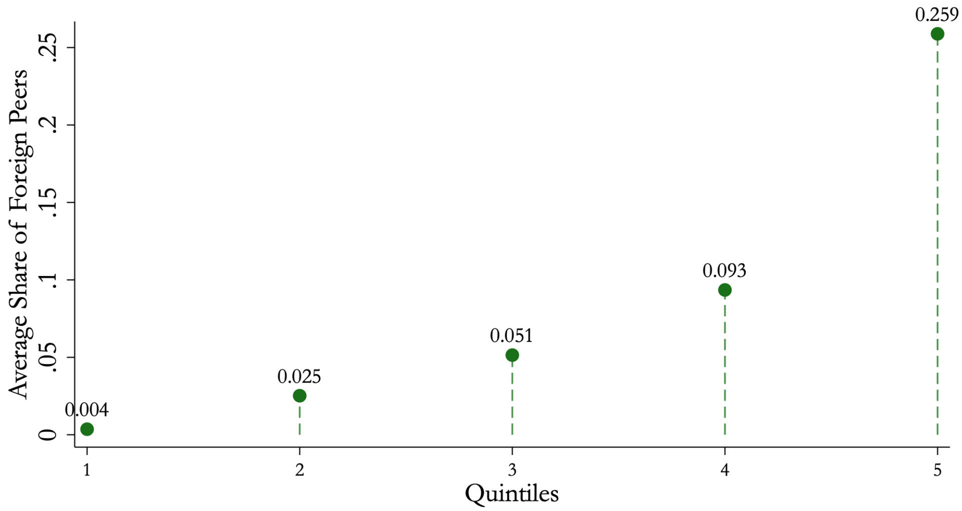
$$Y_{icjt} = \alpha + \sum_{q} \beta_q \mathbb{1}[Q_i = q, q \neq 1] + \theta_{cj} + \lambda_{ct} + \gamma X_i + \delta G_{cjt} + \epsilon_{icjt} \tag{4}$$

where Q_i denotes the i^{th} quintile category of the distribution of the share of foreign peers in the main sample. The lowest quintile, Q1, is the omitted group. Thus, β_Q estimates the impact of foreign peers on domestic students in each quintile (Q2 to Q5) relative to those with foreign peers in Q1. All other terms are the same as Equation 1.

Figures B.2 a and b plot the estimated effects on graduation using the main sample students enrolled in lower-ability and higher-ability courses, respectively. In each figure, the x-axis denotes the quintile measure of the share of foreign peers, where Q1 corresponds to the lowest quintile, and Q5 corresponds to the highest quintile. The y-axis denotes the six-year graduation rate. Compared to domestic students in Q1, domestic students in Q2 have a

4 percentage points lower graduation rate due to exposure to foreign peers in lower-ability courses, This result suggests there is a negative effect of exposure to foreign peers, even at very low levels of share of foreign peers. The negative effect stays roughly the same in Q3 and Q4 before getting much stronger on students in Q5, where the graduation rate is lower by 8.8 percentage points compared to students in Q1. Although the standard errors are large, which is expected, as fewer students in Q5 are enrolled in lower-ability courses, the p-value is 0.11, very close to the 10% significance level. At the same time, there is no effect on students' graduation in higher-ability courses across the entire distribution of the share of foreign peers. These results also indicate that it is not the difference in the foreign share distribution across the lower and higher-ability peer groups that leads to different estimates of peer effects across the two groups. Lastly, the results for effect on retention tell the same story (Figure B.2 c and d).

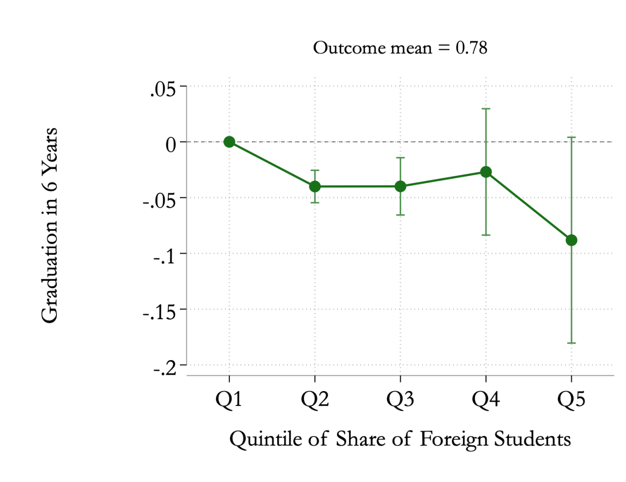
Figure B.1: Average Share of Foreign Peers, By Quintile



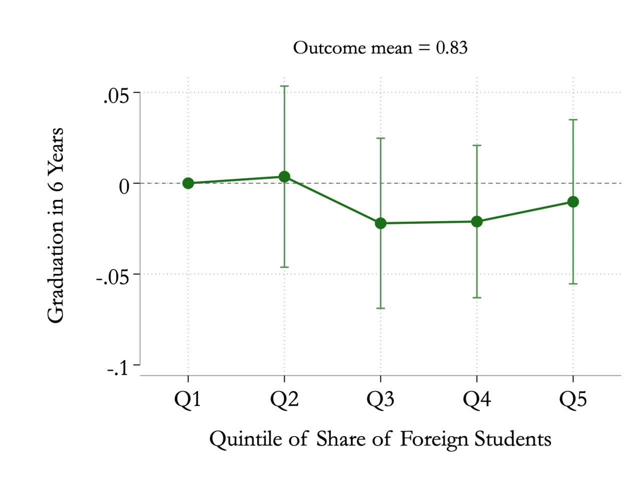
Notes: This figure shows the average exposure to foreign peers (proxied by the share of foreign students in the peer group) in each quintile of the distribution of the share of foreign peers. Source: Authors' calculation using university administrative data.

Figure B.2: IMPACT ON GRADUATION AND RETENTION: QUINTILE MEASURE OF EXPOSURE

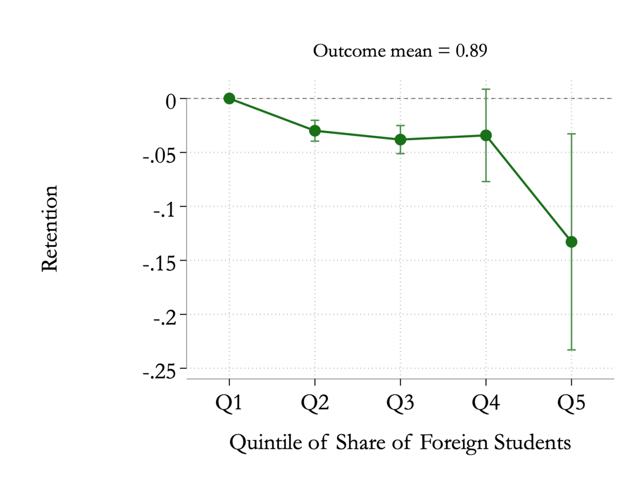
(a) LOWER-ABILITY COURSES



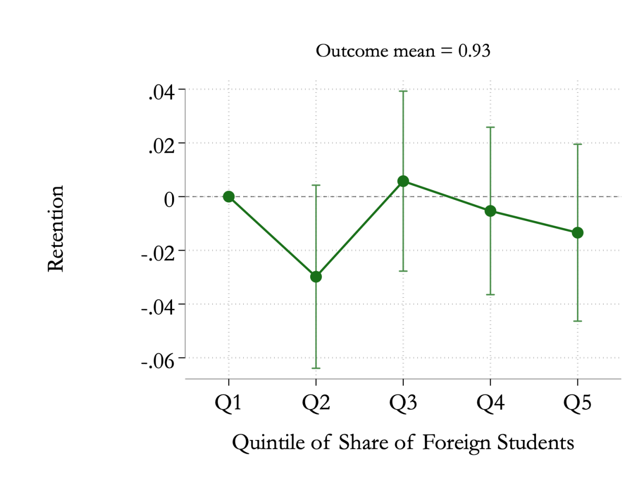
(b) HIGHER-ABILITY COURSES



(c) LOWER-ABILITY COURSES



(d) HIGHER-ABILITY COURSES



Notes: This figure shows the effect of exposure to foreign peers (proxied by share of foreign students in the peer group) on domestic students' six-year graduation rate and retention. The x-axis denotes the quintile measure of the share of foreign students, where Q1 corresponds to the lowest quintile, and Q5 corresponds to the highest quintile. The y-axis denotes the students' six-year graduation rate in B.2 a and b, whereas students' retention rate in B.2 c and d. Each quintile shows the impact of exposure to foreign peers relative to the omitted quintile (Q1). The sub-heading denotes the sample used for the analysis. Lower Ability Courses denote the sample of students enrolled in introductory non-calculus courses. Higher Ability Courses denote the sample of students enrolled in introductory calculus-based courses. All regressions control for course-instructor FEs, course-term FEs, students' own characteristics (race, gender, first-generation flag), students' own math and English ability, peer group size, peer characteristics (share of female students, share of first-generation students), and peer math ability (average math ability). Robust standard errors clustered at instructor level in parenthesis. Sample: First-time freshman domestic students enrolled in introductory math courses in their first term between 2005-2014. Source: Authors' calculation using university administrative data.

B.2 Additional Heterogeneity Analysis

Table B.1: HETEROGENEITY WITH GENDER

	Graduation in 6 years	
	(1) Lower Ability	(2) Higher Ability
Foreign Share	-0.073***	-0.007
	(0.023)	(0.007)
Foreign Share * Female	0.022	0.000
	(0.014)	(0.006)
Mean Dep. Var.	0.78	0.83
N	16771	12475
R-squared	0.04	0.06

Notes: This table reports the heterogeneous effect of exposure to foreign peers (proxied by share of foreign students in the peer group) by domestic students' gender. Each column corresponds to the sample used for the analysis and is denoted in the column header. Lower Ability denotes the sample of students enrolled in introductory non-calculus courses. Higher Ability denotes the sample of students enrolled in introductory calculus-based courses. The regressions include the interaction term of the female dummy and the foreign share, keeping male as the omitted group. All regressions further control for course-instructor FEs, course-term FEs, students' own characteristics (race, gender, first-generation flag), students' own math and English ability, peer group size, peer characteristics (share of female students, share of first-generation students), and peer math ability (average math ability). Robust standard errors clustered at instructor level in parenthesis. Sample: First-time freshman domestic students enrolled in introductory math courses in their first term between 2005-2014. Source: Authors' calculation using university administrative data. Significance: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

B.3 Effect of Exposure to Foreign Peers on Foreign Students

Table B.2: EFFECT OF EXPOSURE TO FOREIGN PEERS ON FOREIGN STUDENTS' GRADUATION

	Lower Ability		Higher Ability	
	(1) Graduation in 6 years	(2) Retention	(3) Graduation in 6 years	(4) Retention
Foreign Share	0.157	0.098*	0.002	0.007
	(0.106)	(0.057)	(0.013)	(0.008)
Mean Dep. Var.	0.66	0.82	0.77	0.91
N	390	390	2980	2980
R-squared	0.20	0.20	0.16	0.16

Notes: This table reports the effect of exposure to foreign peers (proxied by the share of foreign students in the peer group) on foreign students' graduation. Each column group corresponds to the sample used for the analysis and is denoted in the column group header. Lower Ability denotes the sample of students enrolled in introductory non-calculus courses. Higher Ability denotes the sample of students enrolled in introductory calculus-based courses. Each column corresponds to a separate regression of students' outcomes on exposure to foreign peers, with outcome variables denoted by the column headers. All regressions control for course-instructor FEs, course-term FEs, students' own characteristics (race, gender, first-generation flag), students' math ability, peer group size, peer characteristics (share of female students, share of first-generation students), and peer math ability (average math ability). Robust standard errors clustered at instructor level in parenthesis. Sample: First-time freshman foreign students enrolled in introductory math courses in their first term between 2005-2014. Source: Authors' calculation using university administrative data. Significance: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.