Asia Pacific Educ. Rev. (2016) 17:703–718
DOI 10.1007/s12564-016-9461-6

Quasi-experimental evidence of academic peer effects at an Elite University in People's Republic of China

Wei Ha[1]

Received: 10 February 2016 / Revised: 20 October 2016 / Accepted: 24 October 2016 / Published online: 4 November 2016

Abstract This paper examines the effects of roommates on students' academic outcomes exploiting the randomized roommate assignment system at a selective Chinese university. Unlike earlier studies that could not measure students' academic quality precisely, this paper makes two important improvements in measuring their English proficiency and overall academic aptitude. I find that randomly assigned roommates' average pre-treatment academic abilities are not significant determinants of students' academic performance across a number of different specifications. However, students are significantly influenced by roommates' decisions in terms of the number of elective course credits taken and the choice of major.

Keywords Peer effects · Roommates · Academic outcomes

JEL Classification I21 · Z13

Neither the name of the university nor the data can be disclosed due to confidentiality reasons. This research topic was first brought to my attention by Li Han and Tao Li. Comments on an earlier version of this paper by Jin Xiao, Brian Jacob, Sue Dynarski, Anthony Saich and participants at the Second Graduate Seminar on China at Chinese University of Hong Kong (2006) and the Work-in-Progress Seminar at the Kennedy School of Government, Harvard Universities, in 2006 are greatly appreciated.

✉ Wei Ha
wha@pku.edu.cn

[1] Graduate School of Education and Institute of Economics of Education, Peking University, Beijing 100871, People's Republic of China

Introduction

Peers, loosely defined as fellow students, friends, neighbors, and roommates, have long been viewed as having an important influence on one's behavior and learning. The socially optimal method for distributing educational opportunity, as well as the benefits of education policies such as affirmative action, school vouchers, ability tracking, and school choice, hinge to a large extent on the existence, size, and direction of peer effects (Goethals et al. 1999; Hoxby 2002; Winston and Zimmerman 2003; Zimmerman 2003; Griffith and Rask 2014).

Yet the empirical testing of peer effects has proved to be a rather daunting challenge. Manski (1993) proposed that there are at least three competing hypotheses that can explain observed peer effects: "(a) endogenous effects wherein the propensity of an individual to behave in some ways varies with the behavior of the group; (b) exogenous (contextual) effects wherein the propensity of an individual to behave in some way varies with the exogenous characteristics of the group and (c) correlated effects wherein individuals in the same group tend to behave similarly because they have similar individual characteristics or face a similar institutional environment." The effects of these three hypotheses are captured in the following equation.

$$Y = \alpha + \beta E(Y|X) + E(Z|X)\gamma + Z\eta + \mu, \quad E(\mu|X,Z) = X\delta \tag{1}$$

where Y is the outcome variable, (Z, μ) are the student's own attributes that directly affect Y (e.g., socioeconomic status and ability), and X are attributes characterizing the peer group (e.g., a youth's school or ethnic group). Therefore, coefficient γ indicates the exogenous effects when individual behavior varies with the pre-treatment group characteristics. Coefficient β corresponds to the endogenous effects occur when individual behavior varies with the during-treatment behavior of the

group. Finally, correlated effects (coefficient δ) are those driven by the self-selection of individuals into groups.

Since the first proposal of Goethals et al. (1999), studies using (conditional) random assignment of students into housing units to evaluate peer effects in higher education have mushroomed.[1] Because the assignments are by and large random, the correlated effects (potential self-selection into rooms) are eliminated ($\delta = 0$) and Eq. (1) will be reduced to Eq. (2). However, the endogenous effects are still present. As Sacerdote (2011) summarizes, "most papers have one source of exogeneity and do not separately identify the exogenous and endogenous peer effects."

$$Y = \alpha + \beta E(Y|X) + E(Z|X)\gamma + Z\eta + \mu, \quad (2)$$

These studies have so far provided mixed evidence of academic peer effects. Few find consistent evidence that roommates' admission test scores or previous academic ability is linearly related to their own GPA (Sacerdote 2001; McEvan and Soderberg 2006; Carrell et al. 2009; Griffith and Rask 2014). A number of authors find that peer effects, when they do exist, are most pronounced among certain subpopulation groups. For example, Zimmerman (2003) and Winston and Zimmerman (2003) find that students in the middle of the SAT distribution are more susceptible to the influence of poor quality peers. Other studies have found that male or female students are more likely to be influenced by their peers (Duncan et al. 2005; Zimmerman 2003; Han and Li 2009). Another interesting strand examined the peer effects on students' major or job selection (Sacerdote 2011). Marmaros and Sacerdote (2005) found that students not only are influenced by their roommates' career choices but also lean on their peers in the job search process. De Giorgi et al. (2007) used repeated randomization of students to classes at Bocconi University in Italy and found that peers have a significant impact on students' major choices.

In contrast, studies on the effects of roommates on social behaviors (especially those that are considered to be risky behaviors such as binge drinking, marijuana use, unprotected sex, and academic cheating) generally show consistent and strong results (Marmaros and Sacerdote 2006; Duncan et al. 2005; Stinebrickner and Stinebrickner 2008; Carrell et al. 2008; Tsai 2012). Concurrence is also found in other social issues such as sympathy toward the social groups to which their roommates belong and participation in civic activities in which their roommates were active (Duncan et al. 2006; Klofstad 2005).

In Chinese universities, students from the same department/faculty are not only randomly assigned to rooms but also live in much closer proximity to each other, and they live with the same roommates for 4 years with few exceptions.[2] The close proximity and anticipation of long-term relationships should provide them strong incentives to interact. On the other hand, qualitative researchers have provided some counterarguments. Cramped living space may force students to conduct most of their studying in library and lecture halls as opposed to dorms (Wang 2007; Xiao et al. 2015; Zheng 2015). The overcrowding condition of dorms and diverse background and habits of students also breed opportunities for disagreement and personal clashes. The increasing number of single children in the recent cohorts of college students in China may further exacerbate the interpersonal relationship at the dorms (Huang 2007; Chen 2013; Zhao and Su 2015). Last but not the least, competition among them for academic scholarships, which are awarded largely by based on their academic performance, serves as a countervailing factor for the peer effects to take place. Students may not want to share their insights on learning even with their roommates because it may reduce their comparative advantage. This effect should be more prominent in elite universities. Han and Li (2009) were the first to take advantage of the context of an elite Chinese university in Eastern China to examine the residential peer effects among roommates. They found weak roommate effects for females on academic performance and quite robust effects on social outcome such as students' party affiliation. Zhang et al. (2011) used five cohorts of students at the School of Economics and Management of Tsinghua University to examine the peer effects. They found positive but insignificant effects of roommates but strong and significant effects of classmates. Nonetheless, this was based on a rather small sample of one school in Tsinghua University. Lu (2014) used variation in the English proficiency of students' peers caused by the changes in the admission policy of a university in Jiangsu Province in China that brought a large number of specially admitted low-score students into many academic departments. She found that these low-score students significantly reduced the performance of the regular students in a difference-in-difference setup. However, the allocation of low-score students into different departments was unlikely to be exogenous.

The paucity of evidence regarding peer effect of higher education in the Chinese setting is in stark contrast with the policy intention by universities to use room assignment to promote national cohesion and exposure. In addition, China now boasts the world's largest higher education

[1] Literature on peer effects at the K-12 level in the USA takes advantage of either policy-induced exogenous changes at the classroom and school-level or transitory variation in the overall student population or randomized experiments to parse out the causal effect from self-selection (Hoxby 2000; Lefgren 2004; Graham 2005; Heckman 2001; Hoxby and Weingarth 2006; Vardardottir 2013. See Sacerdote 2011 for a detailed review).

[2] Exceptions include switching departments, dropout, suspension, and violence among roommates.

system. Leveraging the peer effects of roommates can be a useful way to improve human capital investment. In this paper, I take advantage of the random assignment of students to rooms at an elite Chinese university where peer quality is better measured compared to Han and Li (2009) and Zhang et al. (2011). My findings suggest that students are likely to influence each other in course and major selection, but they do not influence each other in academic performance. Specifically, students are likely to be influenced by a roommate's decision when it comes to the number of course credits taken and, to a lesser extent, the choice of major. Living with roommates that on average take one SD more elective credits is found to boost students' elective course credits by one-fourth of a SD. However, students who are randomly assigned to live with roommates with higher college admission test scores and English proficiency do not outperform other students in terms of overall GPA and grades for English courses.

The remainder of the paper is structured as follows: "Institutional background of Chinese higher education" section explains the college admissions system in China and how it relates to the room assignment process. "Data description" section describes the data used in this study and confirms the conditional randomness of room assignment. "Empirical results" section describes the empirical strategy to examine the peer effects and provides the empirical results. "Sensitivity and heterogeneity analysis" section presents results from robustness check and sensitivity analysis, while "Conclusions and discussion" section concludes and briefly discusses the implications.

Institutional background of Chinese higher education

China's higher education institutions have a highly centralized and structured enrollment system in which admissions committees at the provincial level operate under the supervision of the Ministry of Education.[3] As a general rule, admission is granted primarily on the basis of students' test scores on the College Admission Test (CAT). The CAT, which is administered by the Ministry of Education in early June each year, has two tracks: arts and sciences. While candidates may sit for only one of the two, they may list up to four universities and departments they wish to enter in order of preference among each of the four tiers of the higher education system. Admissions decisions to a university are primarily based on students' CAT score and their preference ordering of their desired departments.[4] Since the late 1990s, an increasing number of provinces and municipalities have set up their own province-wide examination in lieu of the CAT. In 2004, there were 15 different exams across China. Therefore, CAT scores were not comparable for students from different provinces. Students are usually admitted to a specific department in a university and in turn the departments are in charge of students' study for the next 4 years. Decisions such as financial aid, scholarships, and the opportunity to go directly to graduate school are all made at the department level. In other words, students will compete with their peers in the same department for these honors. This may have implications for how peer effects work in this setting.

The university that this study focuses on is one of the most selective colleges and one of the best research universities in China, with approximately 3000 students in each class. The university sets quotas for each province roughly proportional to their population share.[5] This university also has an early admission track for students with truly outstanding high school academic performance, special athletic talents, and artistic merits.[6]

Students are registered in their home department and are required to take 140 academic credits in order to graduate. There are basically two kinds of courses: required and elective.[7] Both types are comprised of university-wide and department-wide courses. University-wide required courses together total 30–34 of these credits, university-wide elective courses total 16 credits, and department-wide required courses account for the largest part, or 50–54 credits. Department-wide elective courses comprise another 24 credits. Students are required to take core courses in their freshman year, which are primarily required courses. Students need to take at least 14 academic credits in a given semester but cannot go beyond 25

[3] Note that there are several provincial-level administrative units: province, autonomous region, metropolitan city, and special administrative region such as Hong Kong and Macau. For simplicity, I will refer to them as provinces later in the paper.

[4] Each provincial-level unit was assigned a quota of students to be admitted to elite universities, a second quota of students for regular universities within that administrative division, and a third quota of students from other provinces who would be admitted to institutions operating at the provincial level. There is wide heterogeneity in terms of the timing of the application. Some provinces require students to submit applications before they actually take the exams, while others ask students to do so only after the exam.

[5] Given the vast provincial and regional disparity in education quality, this admission system is similar to the percentage plan adopted by California, Florida, and Texas but at a national level. Percent plans means that a certain percent of the highest performing graduates of each high school is admitted to public universities in a state.

[6] Students who are admitted early on the basis of high school academic performance do not have to take the CAT. This creates a missing data problem. I will explain how to compute the missing CAT in Table 4.

[7] The senior thesis makes up another six credits.

academic credits.[8] Courses count for one to four credits. Therefore, the possible number of courses taken within this set of constraints is very wide.

Final course grades are calculated in light of students' performance on problem sets, a mid-term, a final exam, and class participation. Official GPA is calculated using a universal formula that first translates the original grade into a grade point and then weights them by their course credits. This formula suffers from losing useful variation in students' academic performance. Instead, I calculate the weighted average course grade, which is average course grade weighted by their course credit. This weighted average course grade ranging from 0 to 100 will be referred to as GPA thereafter.

Starting in the spring term of the first academic year, students can apply to switch departments, and they also have a choice to enroll in other departments' double major or second-degree programs provided that their academic performance or qualifications meet the requirements of the target departments.[9]

Students will select their majors after the freshman year. Major is a more-refined subfield within the department. For example, students in the physics department have three choices for their major: physics, atmospheric science, and astronomy. The exact timing of this process varies from department to department. Four departments have completed this process by the fall semester of the sophomore year.[10]

College English

College English is a series of required courses for all students except students majoring in English, French, German, and Spanish literature. Depending on their initial English proficiency gauged by the English Placement Exam (EPE) conducted each fall right after their matriculation, students are assigned into four different starting levels of College English: Level 0, Level 1, Level 2, and Level 3. Level 3 is the highest level that students could start in the first term, and it requires a total score of 85 or higher on the EPE. The cutoffs for Level 1 and Level 2 are 59 and 76, respectively. Level 0 is for students whose second language is not English.[11] Students are expected to move up the ladder progressively term by term up to Level 3.[12] After finishing Level 3, students need to choose other elective English courses if their total English credits fall short of 6 credits (equivalent of three courses). All students (excluding those students whose initial second languages are not English) are required to pass the College English Level 4 exam by the time of graduation though no course is provided at Level 4.[13]

Roommate assignment

Unlike the US setting where universities usually ask students to fill out a survey on their housing preferences and assignment is conditional on those factors, no students have any say in choosing their roommates at this elite Chinese university. Rooms are assigned to students by their departments in late August right before their matriculation at the university and students from the same department are assigned together whenever possible. To understand the exact room assignment process, I interviewed each department individually about its assignment mechanism. The majority of the departments deliberately mix students from different provinces with the intention of increasing national cohesion by exposing students to different subcultures in China. However, there are three departments and schools, namely the Department of Economics, the School of Environment, and the School of Journalism, which stratify students by their province of residence. Switching rooms after assignment is very rare because departments strongly discourage students from doing so. Administrative records show only 13 such cases or 0.5% for the first year. This gives us confidence about the randomization of students into rooms. Nonetheless, we offer a formal test later in "Random Assignment Checks" section.

Data description

The data on the 2008 class who entered the university in the fall of 2004 were gathered from the university registrar's office and housing office and include students' basic demographics, housing information, and detailed transcript records for their first 2 years in college.

[8] There have been students who take exceedingly large numbers of courses in the first 2 years and fulfill all academic credits with lackluster grades. The upper limit is designed to discourage students from doing so.

[9] Both programs require a GPA of 2.0 or above. The second-degree program is an expanded program like a double major. It usually takes ten more credits and students who accomplish this will get a degree diploma rather than a certificate of graduation.

[10] The registrar's office had not updated major selection information beyond the fall semester of students' sophomore year when I requested the data.

[11] The number of students who fall into this category is small and therefore this study excludes them from the analysis.

[12] Exceptions will be given to those who can get excellent test scores on both the exam of his or her level and the level he or she wants to bypass at the same time.

[13] Given the fact that many of the students falling into this category have another language as their second language, the university decides that they should be exempted from this requirement.

Outcome variables include students' grades on College English courses and year-by-year GPA as well as cumulative 2-year GPA, number of course credits taken, and major of choice.[14] The academic quality of a student was measured by their CAT scores and their EPE score. Other pre-treatment demographics characteristics include their age, gender, province of origin, party membership, and type of household registration (rural or urban residents). Because of the previously mentioned decentralization of CAT examinations in China since the mid-1990s, the CAT scores are not comparable across provinces for the 2008 class. I created students' percentile rank within the university by assuming that the relative distribution of students' academic ability measured by CAT scores across provinces is stable over time (from the 1999 class to the 2008 class). In other words, if a student ranking in the first percentile from province A was near to the fifth percentile in the science track in the 1999 class in the university, the first percentile student from province A in the 2008 class will also receive a percentile rank of fifth in that university. Students who are admitted on the basis of merit (meaning they do not have to take the CAT in the first place) and therefore missing their CAT score are assigned the highest percentile rank of that province in 1999 class. This is a major improvement in measuring the quality of one's peers with relative precision compared to other studies on peer effects in Chinese universities.

Data from different sources are merged together by person-specific student IDs. I start with a sample of 3215 students. Of these, 170 students are dropped because they are enrolled in a dual-degree program or they live with such students, 22 students are dropped because they belong to earlier classes, along with two students who live alone, and 57 students whose housing data are missing are also dropped. Another 275 are dropped because they are Medical School students and do not report any CAT grade or household registration information. This leaves me with a base sample of 2689 students. This sample will be used to check the randomness of room assignment.

Depending on the outcome variables of interest, I use different samples for statistical analysis. When I focus on the peer effects for students' College English course grades, I use the English Placement Exam (EPE) sample, which includes the College English courses in the first two semesters. One hundred eleven students who major in Western Language and therefore did not take the College English course are dropped. Forty-five students who are missing their EPE score are also dropped. Eleven students are dropped because they are missing their College English course grades. One hundred seventy-six students whose second languages are not English are also dropped. A variable is generated to indicate the number of roommates missing EPE scores. The sample size is reduced to 2346. When the effect of roommates on students' GPA is examined, I use the College Admission Test (CAT) sample, which covers students with comparable CAT scores. The CAT sample has a smaller sample size because the CAT scores are not comparable for students from five provinces even though I go back to 1999 class. Therefore, 455 students are dropped along with 18 students who live primarily with students from those five provinces and therefore have no measure of peer quality, plus 18 students who had no record for courses taken. A variable is generated to indicate the number of roommates missing CAT scores. The final CAT sample size is 2198.

Tables 1 and 2 contain summary statistics for the EPE and CAT samples, respectively. On average, students take 86.7 academic credits in the first 2 years. Students in their sophomore year take slightly fewer credits than in the freshman year. Mean GPA on required courses in the first 2 years is 81.2 with a SD of 6.26. The sophomore year GPA is significantly lower than the freshman year's GPA with a larger SD. For College English courses, 986, 1025, and 335 students are assigned to College English Level 1, Level 2, and Level 3, respectively, for the first term. Approximately, 50% of students enroll as science majors, 30% as social science majors, and 20% as humanities majors.

Given the fact that I am using data from an elite university, there are legitimate concerns about the lack of variation in roommates' academic qualifications in the first place. First, initial English proficiency at this university is fairly dispersed with a mean EPE score of 76.7 and a SD of 7.93 (Table 1). I argue that the province-based quota in the admission system at the university and the huge gap in education quality across China's provinces provide me with more variation than traditionally available from a homogeneous student body.[15]

Random assignment checks

Examination of the housing records shows that the housing data are in line with the departments' policy. Only 0.07% of students live in a two-person room, 5.9% of students live in triples, and 94%—the majority of the student body—share their rooms with three other students. About 86% of students live with other students from the same department,

[14] I use different criteria to calculate students' GPA. I focus on GPA for required courses since it is likely to be the most meaningful comparison. However, the use of a broader measure of GPA for all courses does not change the results substantively.

[15] As a matter of fact, the difference in CAT scores cutoff for students from different provinces to be admitted to the same tier university can be as large as 100 points out of 750 when the scores are comparable. This led to a famous lawsuit in 2001 in which three high school graduates in Shandong sued the Ministry of Education for depriving them of equal education opportunity.

Table 1 Summary statistics for the 2008 class (EPE sample)

	Obs	Mean	SD	Min.	Max.
Dependent variables					
College English score both terms	4341	79.96	6.69	32	96
College English score Term 1	2346	81.07	6.53	32	95
College English score Term 2	1995	78.66	6.65	34	96
Key independent variables					
Own EPE score	2346	76.74	7.93	42	98
Roommates' mean EPE score	2346	75.40	6.38	46	93
Demographics characteristics					
Male	2346	0.59	0.49	0	1
Rural	2346	0.14	0.34	0	1
Age	2346	18.49	0.78	15	23
Han majority	2346	0.93	0.26	0	1
Party membership	2346	0.09	0.29	0	1
Local resident	2346	0.16	0.37	0	1
# Roommates in a room	2346	3.94	0.24	2	4
Science major	2346	3.89	0.33	2	4
Social Science major	2346	0.60	0.49	0	1
Humanities major	2346	0.29	0.45	0	1
# Roommates with EPE score	2346	0.11	0.31	0	1

Academic performance information comes from the University Registrar's Office. The housing office provides students with dorm information. The sample consists of a base sample of students from the 2008 class minus the following five groups: students majoring in German, French and English language (111), students who did not have an EPE score on their record (45) and students who did not report a grade for their College English course (11). Students whose second languages are not English (176) are also dropped. Term 1 College English Course is based on 2346 observations, while Term 2 College English Course is based on 1995 observations

and another 12% of students live in two-department dorms. The mean number of provinces represented in a room is 3.51. It is not surprising since the majority of the departments intend to mix students from different provinces in a room.

However, it is still possible that departments intentionally or subconsciously assigned students of certain characteristics into rooms. Following Sacerdote (2001), students' own characteristics were regressed on roommates' average characteristics conditional on a three-way interaction term between province, department, and gender to examine the randomness of room assignment at this university. The inclusion of a three-way interaction term ensures that identification only comes from the within-department–province–gender cell to reflect the fact that randomization occurs inside each unique combination.

$$X_{ijkl} = \alpha + \beta X_{ijkl}^{\overline{RM}} + \pi_{jkl} + \varepsilon_{ijkl} \quad (3)$$

where X_{ijkl} represents the pre-treatment characteristics (age, ethnicity, residential status, party membership, EPE score, and CAT percentile rank) of student i in department j from province k with gender l. $X_{ijkl}^{\overline{RM}}$ represents the roommates' average characteristics. π_{jkl} is a set of interaction terms between students' department, province, and gender. β is the variable of interest. If β is not significantly different from zero, it means that the roommate assignment process does not generate correlation among observed students' characteristics. Therefore, it is unlikely that the same process will generate correlation among unobserved students' characteristics.

In practice, the number of interaction terms amounts to over a thousand, which renders identification very difficult due to fewer observations within each cell. In other words, there are too many possible combinations of department–gender–province that there may not be enough observations to efficiently estimate the coefficient.

An immediate caveat is that using the three-way interaction terms above is likely to induce negative correlation for students in the departments that stratified students by their province (Kremer and Levy 2003). To see this, think of a case where there are only two male students (AB) from province X who are admitted to department Y, and they are put into a room of two because their department likes to lump students together. If student A has characteristics above the average, student B must have below-average characteristics. The same logic applies to situation of three or four roommates.

Table 2 Summary statistics for the 2008 class (CAT sample)

	Obs	Mean	SD	Min	Max
Dependent variables					
GPA on required courses	2198	81.16	6.26	40.49	95.22
GPA in 2004–2005 on required courses	2198	81.83	6.07	46.22	95.56
GPA in 2005–2006 on required courses	2198	80.01	8.26	6.00	95.23
Total course credits	2198	86.74	7.00	34	129
Course credits in 2004–2005	2198	45.37	3.38	18	66
Course credits in 2005–2006	2198	41.37	5.56	11	91
Independent variables					
Own percentile rank using 1999 data	2198	0.52	0.29	0.00	1.00
Roommates mean percentile rank using 1999 data	2198	0.52	0.21	0.00	1.00
Roommates' mean course credits	2196	86.74	5.84	55.00	107.50
Roommates' mean course credits in 2004–2005	2196	45.37	3.01	27.50	56.00
Roommates' mean course credits in 2005–2006	2196	41.37	4.34	16.50	67.50
Demographics					
Male	2198	0.57	0.50	0	1
Rural	2198	0.15	0.36	0	1
Age	2198	18.51	0.81	14	23
Han majority	2198	0.91	0.29	0	1
Party membership	2198	0.10	0.29	0	1
Local residence	2198	0.19	0.39	0	1
# Roommates in a room	2198	3.94	0.24	2	4
# Roommates with non-missing CAT measure	2198	3.48	0.64	2	4
Science major	2198	0.56	0.50	0	1
Social Science major	2198	0.29	0.46	0	1
Humanities major	2198	0.15	0.35	0	1

Academic performance information comes from the University Registrar's Office. The housing office provides information on students' dorm assignments. The sample consists of the entire base sample of students minus the following groups: students whose CAT is neither available nor easily computed (455) and students who live with them (18). Students who do not report any course grades are dropped as well (18)

Following Kane et al. (2006), I use department–gender plus province fixed effects instead of the three-way interaction fixed effects. This specification allows comparisons across department and gender as long as students are from the same provinces, while the three-way interaction focuses only on students from the same province registered in the same department with the same gender.

$$X_{ijkl} = \alpha + \beta \overline{X_{ijkl}^{RM}} + \tau_{jl} + \upsilon_k + \varepsilon_{ijkl} \quad (4)$$

Table 3 shows the results for Eq. (4) across a variety of pre-treatment student characteristics. None of them shows a significant relationship between students' and their roommates' characteristics at the 5% confidence level using T tests.

It may well be that departments take into account a variety of students' characteristics in the assignment process. Therefore, following McEvan and Soderberg (2006), I regress students' own characteristics on a full set of roommate characteristics. Again, results show that roommates' characteristics have no predictive power on students' characteristics gauged by the P values from the F tests.[16] These randomization checks reassure us that the assignment of students to different rooms is likely to be orthogonal to students' characteristics except those explicitly used (Table 4).

Empirical results

Empirical strategy

In order to quantify the effects of peers on students, I use the "linear in means" approach similar to Eq. (2) where students' academic performance is interpreted as a function

[16] When the dependent variables are dichotomous, I also estimate a probit model in addition to the linear probability model and it does not change the results substantively.

Table 3 Own pre-treatment characteristics regressed on roommates' mean pre-treatment characteristics

	Age	Ethnicity	Rural residence	Party membership	EPE score	CAT percentile rank 1999
Roommates mean characteristics						
Age	−0.005					
	(0.051)					
Ethnicity		0.023				
		(0.046)				
Rural residence			−0.004			
			(0.044)			
Party membership				−0.045		
				(0.048)		
EPE score					0.110	
					(0.078)	
CAT percentile rank 1999						0.040
						(0.029)
N	2689	2689	2689	2689	2535	2216
R^2	0.15	0.17	0.14	0.07	0.20	0.56

Own characteristics are regressed on roommates' average characteristics with two-way interaction fixed effects between department and gender, conditional on students' provinces. Standard errors are in parentheses. ** indicates significance at the 5% level and * indicates significance at the 10% level for the T tests. All regressions are OLS and standard errors are adjusted for heteroskedasticity and clustering at room level

of students' own academic ability, roommates' average academic ability, and other demographics.

$$Y_{ijkl} = \alpha + \beta_1 X_{ijkl} + \beta_2 X_{ijkl}^{\overline{RM}} + Z_{ijkl}\varphi + \pi_{jkl} + \varepsilon_{ijkl} \quad (5)$$

where Y_{ijkl} is the student's GPA (grade for College English course) for student i in department j from province k with gender l; X_{ijkl} is the student's percentile rank in the university (own EPE score); $X_{ijkl}^{\overline{RM}}$ is the roommates' average percentile rank in the university (own EPE score), Z_{ijkl} is a vector of demographic variables indicating the student's ethnicity and whether the student comes from rural areas. Three-way interaction fixed effects between gender, department, and home province are included to reflect the fact that randomization occurs inside each unique combination. As long as randomization is confirmed, the β_2 coefficient on $X_{ijkl}^{\overline{RM}}$ will yield an unbiased estimate of peer effects. It is worth keeping in mind the concern of using the three-way interaction terms mentioned earlier. Therefore, the alternative strategy is to include department–gender fixed effects and province fixed effects separately.

$$Y_{ijkl} = \alpha + \beta_1 X_{ijkl} + \beta_2 X_{ijkl}^{\overline{RM}} + Z_{ijkl}\varphi + \tau_{jl} + \upsilon_k + \varepsilon_{ijkl} \quad (6)$$

In the next section, I show results from these two specifications.[17]

[17] The data for the EPE sample are at the students*term level for the first year while the data for the CAT sample are at the student level.

Peer effects on English proficiency

Table 5 shows the regression results using College English course grade as the dependent variable. In panel 1, data from both fall and spring terms are stacked together with term-specific course-level fixed effects. Panels 2 and 3 present results when regressions are run separately for the two terms with course-level fixed effects. All regressions are OLS and standard errors are adjusted for heteroskedasticity and clustering at room level. Across all panels, Column (1) presents results of the College English grade regressed on own EPE and roommates' average EPE scores. In Column (2) covariates of own characteristics are added to the model. Department fixed effects are added in Column (3) to difference out the potential positive correlation at the department level.[18] Column (4) further controls for department–gender fixed effects. Column (5) best mimics Eq. (6) while Column (6) presents results for Eq. (5). All regressions starting in Column (2) include controls for the number of roommates and the number of roommates who are missing their EPE score. Results from my preferred specification are shown in Column (5).

Across all panels, the effects of roommates' average EPE scores on own College English grade tend to be positive and modest but completely disappear both in the

[18] Students identify four departments in order of preference at this university when they apply for admission. Therefore, we would expect that students share some common characteristics within the same departments.

Table 4 Own pre-treatment characteristics regressed on full set of roommates' mean pre-treatment characteristics

	Age	Ethnicity	Rural residence	Party membership	EPE score	CAT percentile rank 1999
Roommates mean characteristics						
Age	−0.03	−0.036	−0.003	−0.02	0.428	−0.024
	(0.078)	(0.026)	(0.046)	(0.029)	(0.931)	(0.022)
Ethnicity	−0.007	0.007	−0.008	−0.006	−0.335	−0.008
	(0.052)	(0.010)	(0.016)	(0.012)	(0.476)	(0.009)
Rural residence	0.105	0.036	−0.082**	0.042	−1.459	−0.009
	(0.092)	(0.047)	(0.041)	(0.035)	(1.128)	(0.026)
Party membership	−0.01	0.038	−0.026	−0.045	0.951	−0.029
	(0.091)	(0.029)	(0.040)	(0.051)	(1.149)	(0.026)
EPE score	−0.003	0.000	0.001	0.001	0.109	0.002**
	(0.003)	(0.001)	(0.001)	(0.001)	(0.078)	(0.001)
CAT percentile Rank 1999	−0.011	−0.003	−0.047	−0.017	0.007	0.03
	(0.077)	(0.027)	(0.034)	(0.029)	(0.990)	(0.029)
N	2568	2568	2568	2568	2512	2133
R^2	0.16	0.17	0.15	0.07	0.2	0.57
P value for *F* tests	0.8406	0.3821	0.3265	0.5977	0.7891	0.358

Own characteristics are regressed on a full set of roommates' average characteristics with two-way interaction fixed effects between department and gender conditional on students' provinces. Robust standard errors are in parentheses. ** indicates significance at the 5% level and *significance at the 10% level. All regressions are OLS and standard errors are adjusted for heteroskedasticity. *P* value corresponds to an *F* test of joint significance of roommates' characteristics

statistical and economic sense when department fixed effects are added to the model. This reflects the fact that students are not randomly assigned into departments but rather are a self-selected group with similar interests and qualifications (in this case, their initial English proficiency). When two-way or three-way interaction terms are added to the model, the coefficients estimates on roommates' EPE score become even smaller. In any case, none of them are statistically significant.

In contrast, own EPE scores and other characteristics such as gender, ethnicity, and party membership consistently predict students' performance in College English courses across all specifications. Specifically, a one SD (ten points) increase in EPE score translates into an advantage of 4.4 points in College English grade, which is as large as two-thirds of a SD. The results from panel 2 and panel 3 reveal a striking pattern of the effects of own EPE score. The size of the effects shrink by almost 20% in the spring semester compared to the fall semester.

The effects of other demographic indicators are fairly large and stable across the two semesters. Male students score 2.5–2.6 points (one-third of a SD) less than female students. Han majority students and students affiliated with the party enjoy a 1.3 point (one-fifth of a SD) and a 0.8 point (one-sixth of a SD) advantage over ethnic minority and non-party-member students.

Peer effects on GPA

Table 6 shows the regression results using an individual student's GPA from required courses as the dependent variable.[19] In panel 1, a student's GPA is calculated from all the required courses he or she has taken in the first 2 years in college. Panels 2 and 3 present results for freshman year GPA and sophomore year GPA separately. All regressions include controls for the number of roommates and the number of roommates who are missing their percentile rank measures. All regressions are OLS and standard errors are adjusted for heteroskedasticity and clustering at room level. Column (1) to Column (6) follow the same specifications as in previous section on EPE sample. Again, results from the preferred specification are shown in Column (5).

Across all panels, roommates' average percentile rank seems to be negatively correlated with students' GPA although these results are not statistically different from zero. However, the coefficient estimates are large (one-seventh) relative to the effects of students' own percentile rank. The 95% confidence interval for the coefficients

[19] I also use overall GPA as the dependent variable and the results are substantively the same.

Table 5 Peer effects on college English course grade

	(1)	(2)	(3)	(4)	(5)	(6)
Panel 1. College English Grade in Freshman Year (Mean = 80.12, SD = 6.86)						
Own EPE score	0.478**	0.461**	0.454**	0.460**	0.437**	0.435**
	(0.036)	(0.036)	(0.035)	(0.035)	(0.036)	(0.035)
Roommates' mean EPE score	0.077**	0.046**	0.025	0.019	0.011	−0.01
	(0.020)	(0.020)	(0.021)	(0.022)	(0.022)	(0.027)
Male (1 = Yes)		−2.546**	−2.563**			
		(0.261)	(0.270)			
Han majority (1 = Yes)		1.816**	1.737**	1.800**	1.257**	1.346**
		(0.417)	(0.404)	(0.402)	(0.430)	(0.616)
Rural resident (1 = Yes)		0.356	0.381	0.497	0.062	−0.217
		(0.305)	(0.307)	(0.314)	(0.330)	(0.391)
Party member (1 = Yes)		0.856**	0.710**	0.777**	0.802**	0.374
		(0.326)	(0.330)	(0.337)	(0.333)	(0.433)
N	4341	4341	4341	4341	4341	4341
R^2	0.26	0.29	0.31	0.32	0.34	0.54
Panel 2. College English Grade, Fall Semester, Freshman Year (mean = 80.05, SD = 6.66)						
Own EPE score	0.529**	0.509**	0.506**	0.510**	0.476**	0.450**
	(0.039)	(0.038)	(0.038)	(0.038)	(0.039)	(0.043)
Roommates' mean EPE score	0.065**	0.033*	0.015	0.01	0.004	−0.009
	(0.021)	(0.020)	(0.022)	(0.023)	(0.023)	(0.031)
Male (1 = Yes)		−2.469**	−2.469**			
		(0.245)	(0.270)			
Han majority (1 = Yes)		1.723**	1.661**	1.740**	1.365**	1.262*
		(0.443)	(0.436)	(0.433)	(0.475)	(0.718)
Rural resident (1 = Yes)		0.499	0.535*	0.651**	0.118	−0.027
		(0.312)	(0.316)	(0.323)	(0.339)	(0.449)
Party member (1 = Yes)		0.839**	0.692**	0.793**	0.698**	0.499
		(0.339)	(0.348)	(0.354)	(0.355)	(0.477)
N	2346	2346	2346	2346	2346	2346
R^2	0.34	0.38	0.39	0.4	0.43	0.64
Panel 3. College English Grade, Spring Semester, Freshman Year (Mean = 80.12, SD = 6.86)						
Own EPE score	0.425**	0.412**	0.401**	0.407**	0.398**	0.408**
	(0.040)	(0.039)	(0.039)	(0.039)	(0.040)	(0.050)
Roommates' mean. EPE score	0.091**	0.060**	0.036	0.029	0.019	−0.015
	(0.024)	(0.023)	(0.025)	(0.026)	(0.027)	(0.038)
Male (1 = Yes)		−2.680**	−2.671**			
		(0.323)	(0.336)			
Han majority (1 = Yes)		1.911**	1.807**	1.852**	1.102**	1.306
		(0.508)	(0.493)	(0.498)	(0.527)	(0.884)
Rural resident (1 = Yes)		0.202	0.22	0.331	0.005	−0.419
		(0.379)	(0.384)	(0.392)	(0.420)	(0.585)
Party member (1 = Yes)		0.887**	0.716	0.745*	0.911**	0.127
		(0.442)	(0.442)	(0.450)	(0.448)	(0.695)
N	1995	1995	1995	1995	1995	1995
R^2	0.11	0.15	0.17	0.19	0.22	0.52

This table shows the regression results using College English course grade in the freshman year as the dependent variable. Students' demographic variables are controlled for in Column (2). Department fixed effects are added in Column (3). Column (4) controls for department–gender fixed effects. Column (5) includes the interaction terms between department and gender as well as the province fixed effects. Column (6) includes the three-way interaction terms

** Significance at the 5% level, * significance at the 10% level

Table 6 Peer effects on GPA (first 2 years)

	(1)	(2)	(3)	(4)	(5)	(6)
Panel 1. First 2 year's GPA (Mean = 81.16, SD = 6.26)						
Own percentile rank	5.024**	5.025**	4.816**	4.753**	5.202**	5.352**
	(0.448)	(0.445)	(0.474)	(0.480)	(0.703)	(0.979)
Roommates' mean percentile rank	−0.152	0.216	−0.257	−0.363	−0.747	−0.244
	(0.653)	(0.633)	(0.690)	(0.677)	(0.681)	(1.030)
Male (1 = Yes)		−2.254**	−2.242**			
		(0.293)	(0.303)			
Han majority (1 = Yes)		2.475**	2.369**	2.431**	2.017**	1.765**
		(0.435)	(0.432)	(0.432)	(0.450)	(0.644)
Rural resident (1 = Yes)		−1.244**	−1.214**	−1.074**	−1.529**	−1.816**
		(0.382)	(0.382)	(0.389)	(0.399)	(0.537)
Party member (1 = Yes)		1.189**	1.250**	1.381**	1.375**	1.442**
		(0.355)	(0.368)	(0.370)	(0.360)	(0.527)
N	2198	2198	2198	2198	2198	2198
R^2	0.05	0.11	0.13	0.15	0.19	0.43
Panel 2. Freshman year's GPA (Mean = 81.83, SD = 6.07)						
Own percentile rank	5.263**	5.183**	4.815**	4.734**	4.875**	5.398**
	(0.440)	(0.432)	(0.460)	(0.464)	(0.670)	(0.932)
Roommates' mean percentile rank	0.430	0.718	−0.046	−0.185	−0.588	−0.024
	(0.641)	(0.620)	(0.670)	(0.654)	(0.657)	(0.983)
Male (1 = Yes)		−1.881**	−2.047**			
		(0.295)	(0.310)			
Han majority (1 = Yes)		2.688**	2.551**	2.599**	2.154**	1.797**
		(0.45)	(0.447)	(0.444)	(0.451)	(0.641)
Rural resident (1 = Yes)		−1.069**	−0.956**	−0.823**	−1.225**	−1.557**
		(0.354)	(0.356)	(0.366)	(0.376)	(0.490)
Party member (1 = Yes)		1.153**	1.179**	1.326**	1.305**	1.223**
		(0.361)	(0.372)	(0.372)	(0.367)	(0.504)
N	2198	2198	2198	2198	2198	2198
R^2	0.07	0.11	0.15	0.17	0.22	0.47
Panel 3. Sophomorn year's GPA (Mean = 81.83, SD = 6.07)						
Own percentile rank	4.792**	4.931**	4.883**	4.840**	5.630**	5.076**
	(0.589)	(0.596)	(0.633)	(0.645)	(0.981)	(1.377)
Roommates' mean percentile rank	−0.979	−0.469	−0.669	−0.719	−1.093	−0.553
	(0.805)	(0.792)	(0.859)	(0.857)	(0.862)	(1.321)
Male (1 = Yes)		−2.875**	−2.574**			
		(0.364)	(0.348)			
Han majority (1 = Yes)		2.106**	2.015**	2.102**	1.736**	1.517**
		(0.500)	(0.491)	(0.490)	(0.529)	(0.764)
Rural resident (1 = Yes)		−1.536**	−1.639**	−1.496**	−2.067**	−2.308**
		(0.507)	(0.503)	(0.506)	(0.525)	(0.728)
Party member (1 = Yes)		1.342**	1.412**	1.535**	1.560**	1.852**
		(0.426)	(0.435)	(0.440)	(0.436)	(0.734)
N	2198	2198	2198	2198	2198	2198
R^2	0.03	0.07	0.1	0.11	0.14	0.35

This table shows the regression results using GPA on required courses in the freshman and sophomore years as the dependent variable. Students' demographic variables are controlled for in Column (2). Department fixed effects are added in Column (3). Column (4) controls for department–gender fixed effects. Column (5) includes the interaction terms between department and gender as well as the province fixed effects. Column (6) includes the three-way interaction terms

** Significance at the 5% level, * significance at the 10% level

ranges from −2.08 to +0.59.[20] Again, own percentile rank and other student characteristics such as gender, ethnicity, and party membership consistently predict students' GPA in required courses. Specifically, a one SD (29 percentile rank higher) increase in percentile rank translates into an advantage of 1.51 points in GPA, which is as large as a quarter of a SD. The directions of the effects of other demographic indicators are the same as reported earlier except that the rural students performed worse than urban students.[21] Male students score 2.2 points (one-third of a SD) less than female students. Han majority students and students affiliated with the party enjoy 2.0 (one-third of a SD) and 1.4 points (one-fifth of a SD) advantage over ethnic minority and non-party-member students.

Peer effects on numbers of course credits taken

The number of academic credits completed can be viewed as another measure of students' progress in college. Meanwhile, students also need to strike a balance between the speed of progress and the grade received because grades are an important determinant of merit-based scholarships, future job placement, and the opportunity to attend graduate school, etc. I expect that students will consult each other about the process and share information on the courses of high interest. However, this benign description of roommates is not indispensable for peer effects to happen. The influence of one's roommates on the number of course credits taken by a student may come from information flow from roommates' course-taking behavior, peer pressure, or simply herding behavior.

Table 7 shows regression results where students' elective course credits completed in the first 2 years, freshman year, and sophomore year are regressed on roommates' average elective course credits. Students' percentile rank and demographic variables are controlled for in Column (2). Department fixed effects are added in Column (3) to control for the different workload or distribution of course credits over 4 years across departments. The usual two-way and three-way interaction terms are added in Columns (5) and (6), respectively.

Across all specifications, roommates' average course credits are positively correlated with students' own course credits. Over a two-year period, having roommates that on average take 8.15 more credits (one SD) in electives will increase a student's course credits by 0.283 (one-fourth of a SD). When freshman year and sophomore year data are examined separately, the peer effect is found to be slightly stronger in the freshman year than in the sophomore year. The number of elective course credits taken is not determined by students' own percentile rank. The number of course credits also does not appear to differ across students' gender, residential status, party membership status, and ethnicity; therefore, their results are not reported here.[22] Since there is no selection on observables, it is unlikely to have selection on unobservables. This gives me confidence on the causal nature of my estimates.

Peer effects on major selection

The selection of major is likely to determine students' academic life in college and their professional careers later. This section examines the role of roommates on this process. I take advantage of the largest department at this university, which assigns students to four different majors at the end of their freshman year. There are two very large majors, each consisting of around 110 students (Majors A and B). A smaller major has 70 students (Major C) and the smallest major only has 30 students (Major D). Dummy variables indicating whether students select the major as their choice are created for each student–major pair. This dummy variable is summed at room level to calculate the number of roommates (excluding the student herself) who select a particular major.

Table 8 presents results where dummy variables indicating whether a student selects this major as the major of choice are regressed on a set of dummy variables for the number of roommates who select the same major and students' own freshman year GPA. Specification (2) controls for other demographics and the number of roommates that come from this department. Province fixed effects are added in specification (3). The number of roommates that select a certain major is a significant determinant of own major of choice. The set of dummy variables for number of roommates in the same major are jointly statistically

[20] It is possible that the way percentile rank is calculated through the cross-ranking method generates too much noise in the measurement of peer academic ability and therefore measurement error attenuates the coefficient estimate. Also the EPE exam is designed for the purpose of screening entering students and therefore its variation is likely to reflect the true preparedness of a student for college life. I show results where both own and roommates' EPE score replaces percentile rank measures as key independent variables. There is some evidence that the freshman year GPA is positively correlated with roommates' average EPE score but it is no longer statistically different from zero once I limit the identification to students in the same department with the same gender (results are available from the authors upon request).

[21] In the previous section, it is found that rural students performed at least as well as urban students with similar initial English proficiency. This result is primarily driven by the fact that rural students tend to be concentrated in the first level. Altogether it serves as a reminder that rural students remain a disadvantaged group at this university.

[22] When credits on required courses are also included in the analysis, the effects are much smaller. In the 2-year period, having roommates that on average take 5.84 more credits (one SD) will increase students' overall course credits by 1.12 (one-sixth of a SD).

Table 7 Peer effects on electives credits

	(1)	(2)	(3)	(4)	(5)	(6)
Panel 1. Elective course credits in the first 2 years (Mean = 21.01, SD = 9.12)						
Roommates mean course credits	0.801***	0.784***	0.310***	0.292***	0.283***	0.284***
	(0.018)	(0.018)	(0.041)	(0.042)	(0.041)	(0.049)
Own percentile rank		0.074	0.523	0.535	−0.833	−0.245
		(0.475)	(0.459)	(0.461)	(0.629)	(0.858)
R^2	0.51	0.52	0.63	0.64	0.64	0.77
Panel 2. Elective course credits in the freshman year (Mean = 6.21, SD = 4.47)						
Roommates mean course credits	0.691***	0.684***	0.296***	0.273***	0.268***	0.248***
	(0.031)	(0.032)	(0.046)	(0.048)	(0.047)	(0.056)
Own percentile rank		0.254	0.273	0.268	−0.598	−0.677
		(0.249)	(0.257)	(0.261)	(0.430)	(0.539)
R^2	0.35	0.35	0.45	0.46	0.48	0.67
Panel 3. Elective course credits in the Sophomore year (Mean = 14.79, SD = 7.79)						
Roommates mean course credits	0.823***	0.809***	0.271***	0.255***	0.249***	0.190***
	(0.016)	(0.017)	(0.040)	(0.042)	(0.041)	(0.045)
Own percentile rank		−0.173	0.242	0.26	−0.236	0.455
		(0.378)	(0.357)	(0.359)	(0.462)	(0.663)
R^2	0.55	0.55	0.68	0.68	0.69	0.8

Students' own course credits are regressed on roommate's average course credits. Students' percentile rank and demographic variables are controlled for in Column (2). Department fixed effects are added in Column (3). Column (4) controls for department–gender fixed effects. Column (5) includes the interaction terms between department and gender as well as the province fixed effects. Column (6) includes the three-way interaction terms, respectively. The number of observations is 2194 due to deletion of students whose only roommate does not report any course information

*** Significance at the 1% level, ** Significance at the 5% level, * significance at the 10% level

significant across specifications and majors at the 10% level. Having two roommates in a major will increase a student's probability of selecting the same major except for the smallest major D. However, the effect of having one or three roommates in a major differs from major to major. Own freshman year GPA consistently predicts students' major choices. Students who select major C tend to have a higher GPA, whereas majors A and B are more likely to be the choices of low-performing students.

Sensitivity and heterogeneity analysis

Several previous studies suggest that peer effects are heterogeneous and/or nonlinear among different populations. This section discusses the heterogeneity and nonlinearity of peer effects.

First, I include the quadratic terms of roommates' average percentile rank or EPE score in the regression. The quadratic terms are not jointly significant with a p value of 0.534 and 0.201 for the EPE sample and CAT sample, respectively when department–gender and province fixed effects are controlled for (see column 2 in Table 9). This is true across specifications as long as department fixed effects are included. I also try to use different functional forms of roommates' average characteristics to account for the fact that maybe only the really "good" or "bad" roommates matter. However, when students' own GPA is regressed on a dummy variable indicating whether a student has a really good (top 10 percentile) or a really bad (bottom 10 percentile) roommate conditional on the usual covariates, the coefficient is statistically insignificant from zero (results not shown here).

I explore the heterogeneous peer effects with respect to students' gender and department type by running separate regressions for each subpopulation. Results from columns 3–4 in Table 9 suggest that neither male nor female students are affected by their roommates' academic ability. No peer effects are found for students who are enrolled in science or non-science departments. I also interact students' own EPE score and CAT percentile rank with their roommates' average EPE score and CAT percentile rank to examine whether the peer effects differ by students' initial academic ability. However, the results indicate that there is no such evidence. The t statistic for the interaction term is never larger than 0.5. Also, the interaction terms and the level of roommates' average EPE score or CAT percentile rank are not jointly significant. As a final robustness check,

Table 8 Peer effects on major choice (results for linear probability model)

	Major A			Major B			Major C			Major D		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
1 Roommate same major	−0.074	−0.067	−0.091	−0.033	−0.052	−0.049	0.034	0.017	0.013	0.115**	0.112**	0.099**
	(0.061)	(0.062)	(0.067)	(0.057)	(0.056)	(0.058)	(0.046)	(0.047)	(0.050)	(0.051)	(0.050)	(0.049)
2 Roommates same major	0.116	0.112	0.113	0.189**	0.198**	0.220**	0.125	0.102	0.106	−0.080**	−0.082**	−0.067*
	(0.075)	(0.076)	(0.078)	(0.078)	(0.080)	(0.084)	(0.076)	(0.079)	(0.079)	(0.018)	(0.022)	(0.038)
3 Roommates same major	−0.081	−0.098	−0.09	0.159	0.16	0.172	−0.196**	−0.213**	−0.210**			
	(0.119)	(0.120)	(0.133)	(0.127)	(0.124)	(0.123)	(0.046)	(0.053)	(0.076)			
1st Year own GPA	−0.014**	−0.014**	−0.015**	−0.009**	−0.009**	−0.011**	0.021**	0.022**	0.021**	0.001	0.001	0.004
	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)	(0.005)	(0.003)	(0.003)	(0.004)	(0.002)	(0.003)	(0.003)
P value for *F* tests	0.046	0.063	0.032	0.018	0.009	0.008	0.000	0.000	0.009	0.000	0.000	0.012
Observations	329	329	329	329	329	329	329	329	329	329	329	329
R^2	0.05	0.06	0.16	0.05	0.08	0.20	0.12	0.13	0.24	0.03	0.04	0.20

A dummy variable indicating whether a student select this major as major of choice is regressed on a set of dummy variables for number of roommates select the same major and own freshman year GPA. All regressions are OLS. Specification (2) control for other demographics and number of roommates from this department. Province fixed effects are added in specification (3). *P* value corresponds to the *F* test of joint significance of the set of dummy variables for number of roommates in a specific major

** Significant at 5% level, * significant at 10% level

departments that stratify students are excluded from the sample to see whether the negative correlation among roommates biases downward the estimates for peer effects. No such evidence is found either.

Conclusions and discussion

Since the late 1990s, research on peer effects in higher education in the USA has mushroomed, taking advantage of the randomization of students into dorms or squadrons. Previous literature has provided mixed evidence regarding the effect of roommates on students' academic outcomes but consistent effects on social outcomes. A couple of earlier studies examining peer effects in the context of elite Chinese universities show no or limited effects of roommates on one's academic performance (Han and Li 2009; Zhang et al. 2011). However, the quality of peers was not precisely measured in their studies.

This paper takes advantage of the roommate assignment system in a highly selective Chinese university to reexamine peer effects on academic performance among college roommates. In particular, I am able to measure students' academic ability with more precision and confidence. First of all, students' English proficiency was gauged by the English Placement Exam (EPE) conducted each fall right after their matriculation for all students, a common practice largely overlooked by earlier studies. Second of all, unlike earlier studies that turn a blind eye to the fact that CAT scores are not comparable across provinces for the 2008 class, I created students' percentile rank within the university by assuming that the relative distribution of students' academic ability measured by CAT scores across provinces is stable over time (from the 1999 class to the 2008 class).

I find that randomly assigned roommates' average pretreatment academic abilities are not significant determinants of students' academic performance across a number of different specifications. Particularly, students who are randomly assigned to live with roommates with higher College Admission Test scores and English proficiency do not seem to outperform other students in terms of overall GPA and course grade for English courses.

On the other hand, students are indeed influenced by roommates' decisions when it comes to the number of course credits taken and, to a lesser extent, major choice. Living with roommates that on average take one SD more credits in elective courses is found to boost students' elective course credits by one-fourth of a SD.

Yet there are a couple of important caveats with regards to the findings of this paper. First, the focus on one elite Chinese university begs the question of the

Table 9 Sensitivity analysis of peer effects on college English grades and GPA

	Full sample		Heterogeneous treatment effects			
	Linearity	Nonlinearity	Male	Female	Science	Non-science
Panel 1. EPE sample (dependent variable: College English Grade)						
Own EPE score	0.437**	0.438**	0.474**	0.374**	0.511**	0.346**
	(0.036)	(0.036)	(0.050)	(0.045)	(0.053)	(0.039)
Roommates' mean EPE score	0.011	0.312	−0.003	0.043	0.016	0.015
	(0.022)	(0.289)	(0.030)	(0.032)	(0.031)	(0.031)
Roommates' mean EPE score squared		−0.002				
		(0.002)				
N	4341	4341	2588	1753	2607	1734
R^2	0.34	0.34	0.30	0.34	0.33	0.39
P value		0.5336				
Panel 2. CAT sample (dependent variable: GPA in the first 2 years)						
Own percentile rank	5.202**	4.755**	7.071**	1.342	5.443**	4.015**
	(0.703)	(0.676)	(0.924)	(0.906)	(1.015)	(0.930)
Roommates' mean percentile rank	−0.747	−4.276	−0.515	−1.334	−0.816	−0.735
	(0.681)	(2.702)	(1.033)	(0.845)	(0.935)	(0.923)
Roommates' mean percentile rank squared		3.377				
		(2.556)				
N	2198	2198	1250	948	1231	967
R^2	0.19	0.22	0.25	0.15	0.23	0.26
P value		0.201				

All regressions are OLS and standard errors are adjusted for heteroskedasticity and clustering at the room level. All regressions control for department–gender fixed effects plus province fixed effects. The first column of both panels repeats the regression results from Column (5) in Tables 5 and 6. Column (2) reports the estimates when the squared term of roommates EPE score or average percentile rank are added. *P* values correspond to the *F* test of the joint significance of quadratic terms for roommate average percentile rank. The next two columns report the estimate of peer effect by students' gender. Note that here the two-way interaction terms are reduced to department fixed effects. The last two columns report results for students from the science department and non-science department, respectively

** Significance at the 5% level, * significance at the 10% level

external validity of the results. One has to be cautious in extrapolating the results to other higher education settings in China. Second, the paper's findings will have more policy relevance if it is supplemented by qualitative research that decipher the black box in peer effects or the lack of it among college roommates in China. For example, do the findings suggest that students are more likely to be influenced by roommates' behavior that is easily observed? Is there any heterogeneity in terms of susceptibility of students to peer effects (e.g., certain students are more likely to be influenced by their peers)? Do we know the causal mechanisms behind the observed positive correlation between students' choice of major and their peers'? Is this due to peer influence or is this decision of the students made simply out of convenience to save time on procuring study materials, sharing information on subject matters, and opportunities for studying interactions? These are all important directions for future research.

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