The Impact of Study Groups and Roommates on Academic Performance

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Abstract

This paper uses random assignment of students to investigate the impact of study groups and roommates on academic achievement. We find that informal social interaction with roommates has a significant positive impact on academic achievement while study group peers have no discernible impact, a result driven by group heterogeneity in ability. We also find that lower ability students benefit from high ability students but not vice versa.

Keywords: Peer effects. Social networks. Management education.

JEL Codes: I23, L23.

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1 Introduction

The effect of peers on individual academic outcomes is a key research question addressed by a growing empirical literature.[1] While this literature has established that peer effects are significant in academic settings, less is known about the relative influence of interaction between study groups versus roommates. This paper analyses the simultaneous impact of formal study groups and informal roommates on grades at a business school. To our knowledge, this is the first paper that examines the simultaneous effect of multiple peers groups on educational outcomes of students.

There are a number of reasons to compare the influence of classroom peers to those in residential settings. First, the incentives for peer engagement might be different in the two settings. In our setting, members of a study group receive a joint grade on homework assignments, raising both the possibility of greater cooperation as well as free-riding that may result in intra-group conflict. Conversely, roommates have no explicit incentives to work with each other. While this might lead to under-provision of peer input, the absence of formal incentives might imply that pro-social norms are more effective. Second, the conditions under which study groups and roommates interact might be systematically different. One example of this difference is that roommates might spend more time with each other compared to study groups, leading to greater opportunities for students to learn from each other. Finally, study groups and roommates might distribute tasks differently in order to realize gains from trade. For example, members of a study group might divide homework by academic specialization, with students having stronger math background completing quantitative assignments and those with stronger verbal ability finishing writing assignments. Conversely, the space for making side payments might be different for roommates and include non-academic domestic work. For example, a roommate might promise to help with homework in return for assistance with cooking, an option that study group members might not have.

We report three main findings. First, we find that interaction with roommates has a positive impact on academic achievement whereas the effect of study groups is small and insignificant. Specifically, the impact of the mean GMAT score of roommates on grades is one-third of the

[1] See surveys of the literature on peer effects in education by Epple and Romano (2011) and Sacerdote (2011).

impact of a student's own GMAT score. Second, we find that greater variance in roommate ability is positively associated with higher grades. Third, we find that the impact is heterogenous in student ability, where academically weaker students benefit more than the stronger students from their peers. We also examine the impact of the strength of group incentives in place, the effect of decreasing interaction costs within the study group, and including alternative peer characteristics in the specification. The robustness checks are consistent with our main finding that immediate roommates have a significant impact on student outcomes, but the study group peers do not.

The source of the data for our analysis, described in more detail in subsequent sections, is a full-time, residential graduate general management program located in India. A key advantage of this institutional setting is that an administrator randomly assigns students to two separate groups – a study group and a residential quad. The study group typically consists of four or five students from the same class section who are required to jointly complete formal academic tasks such as homework assignments for which they receive common grades. The residential group is formed by the assignment of individuals to apartments shared by three other students (forming "quads"). In contrast to the study group, roommates have no formal academic commitments towards each other, and interact voluntarily. This assignment helps us to address two out of the three concerns raised by Manski (1993) – "endogenous group membership" where identification of peer effects in most observational data is difficult because of the tendency of individuals with shared attributes to associate with each other, and "correlated unobservables" which is the possibility of incorrectly attributing the influence of shared environment to the influence of peers. However, we cannot separately identify the direction of peer effects within the group since we estimate reduced form regressions.

There are several further advantages to using this data for answering our research question. First, as mentioned previously, in our setting students are simultaneously and exogenously assigned to study groups and roommates, where both sets of peers are in the same program and therefore share similar characteristics. This helps to overcome identification issues that may arise if different sets of peers are composed from different populations. For example, if study groups are composed

of students from the same major, but no such restriction is placed on roommates, then identifying study group versus residential effects differently from composition effects will be difficult. Second, given the specialized nature of the graduate program, it is unlikely that off-campus social networks influence our main measure of student performance, which is grades earned in the core terms. Finally, we have complete administrative data which contains a rich set of covariates allowing us to control for other factors that might potentially impact academic outcomes in this setting.

Our study bridges the literature on peer effects by considering the simultaneous effects of multiple peer groups.[2] Pioneered by Sacerdote (2001), the most convincing studies of peer effects in academic settings avoid endogenous selection into groups by exploiting exogenous or random assignment of students to various groups.[3] This strategy is used to estimate the impact of roommates in residential college dormitories on academic and career outcomes (Zimmerman 2003; Foster 2006; Stinebrickner and Stinebrickner 2006; Lyle 2007; Carrell, Fullerton, and West 2009; De Giorgi, Pellizzari, and Redaelli 2010; Garlick 2012). Carrell, Fullerton, and West (2009)'s study set at the US Air Force Academy compares peers in the same cohort (other freshmen) to peers who are upperclassmen, as well as peers who are roommates to other members of the squadron. They do not report significant roommate effects, but large effects associated with squadron peers beyond roommates, emphasizing the importance of multiple networks in our understanding of peer effects. Conversely, Zimmerman (2003) finds that roommates' SAT verbal scores are positively associated with academic performance in the freshman year at Williams College. These findings echo Stinebrickner and Stinebrickner (2006) who report that roommates' ACT scores are correlated with first semester grades at Berea College. In their survey of the literature, Epple and Romano (2011) conclude that while roommate peer effects are present, peer influence is not well captured by measured academic aptitude of the roommates.

One of the few experimental studies featuring random assignment to classrooms is Duflo, Du-

[2]Although in their setting the formation of connections is unlikely to be exogenous, Chidambaran, Kedia and Prabhala's (2011) study of CEOs and directors compares the impact of professional connections formed by serving on corporate boards with the influence of social networks formed in college on corporate fraud.

[3]Alternative methodologies use instruments for peer characteristics (Evans, Oates, and Schwab 1992), or include fixed-effects for group and institution-specific characteristics (Hanushek, Kain, Markman, and Rivkin 2003; Arcidiacono and Nicholson 2005; Lavy and Schlosser 2011).

pas, and Kremer (2011) who assign second-year primary school students to sections.[4] They compare the effect of "tracking", i.e. assigning students after sorting on the basis of first-year grades to randomly mixing students, and find significantly better educational outcomes for tracked students.

In alternative settings related to our work, the literature examines the design of incentives for joint output by a peer group. For example, Lavy (2002) evaluates a team-based incentive program for teachers in Israel and finds that such incentives improve academic performance of the students and are cost-effective compared to increasing school resources. Muralidharan and Sundararaman (2011) compare the effectiveness of group versus individual bonuses for teachers in India and found no significant difference in performance of students in the two treatments. In contrast to teachers, Blimpo (2010) compares the effectiveness of team and individual incentives for secondary school students in Benin. Jain and Narayan (2011) conduct a laboratory experiment to address distributional issues that emerge when teachers' compensation is in the form of team incentives. They find that the design of team incentives is associated with differential investments by the social (in this case, caste) identity of the students.

The rest of the paper is organized as follows. Section 2 introduces the institutional setting where the study is located, the assignment process that is the heart of our identification strategy and a description of the data. Section 3 analyzes this data in detail, including a discussion of the results and robustness checks. Section 4 concludes with a discussion of the policy implications.

2 Institutional description and data sources

Estimating peer effects in academic outcomes requires data where each student is reliably and exogenously matched with a set of peers. In order to test the relative impact of peer groups in classroom versus residential environments, we need at least two sets of such peer assignments in the dataset. The dataset should contain information from each node in the network, not from a

[4]Lerner and Malmendier (2012) and Shue (2013) use the random assignment of students to first year sections at Harvard Business School to estimate the impact of peers on non-academic outcomes such as entrepreneurship, executive compensation and firm performance.

partial sample of the network, to avoid biased estimates in case the structure of the network is inaccurately or incompletely mapped (Chandrasekhar and Lewis 2011). Finally, the dataset should contain information on academic and career outcomes, as well as a rich set of covariates that describe each student's ability, skills, professional background and demographic characteristics. The next three sections describe the data that satisfies these requirements, and allows for estimation of the size of peer effects.

2.1 Institutional description

Our data source is the flagship post-graduate business program (PGP) at the Indian School of Business (ISB). ISB is a large, independent provider of post-graduate management education established in 2001 with a one year, full-time residential diploma program. Since 2009, the *Financial Times* newspaper has ranked the program among top 40 MBA programs in the world. ISB was established in 2001 in academic collaboration with the Wharton School of the University of Pennsylvania, Kellogg School of Management at Northwestern University and London Business School (LBS), and shares many institutional and academic policies with these schools.

An application to ISB consists of GMAT scores, essays, letters of recommendation, undergraduate and graduate transcripts and an interview.[5] Although drawing from a pool of applicants predominantly from India, Online Appendix A shows that student characteristics at ISB are comparable with those at a number of leading international business schools. Classes at ISB are held for 50 weeks without any significant break, and are divided into eight terms of six weeks each. In the first four terms, students take a common "core" of 16 non-elective classes covering a range of management topics. In the next four terms, students choose various elective courses that allow them to concentrate (or "major") in the areas of entrepreneurship, finance, information systems, operations management, marketing or strategy.

[5]In contrast to many colleges and universities located in India, ISB does not implement preferential affirmative action quotas for Scheduled Caste or Scheduled Tribe candidates. Sekhri (2011) analyzes peer effects with affirmative action and finds that better average quality of high caste students has a negative impact on the performance of low caste students.

Instructors at ISB award course grades on a four point scale. The highest grade is an A, corresponding to 4 grade points. Below this are A- (3.5 grade points), B (3 points), B- (2.5 points), C (2 points), D (1 point) and F (0 points). An F is a failing grade which requires the student to repeat the course. Instructors are required to maintain a class grade point average between 3.25 and 3.30 across all sections that they teach. While student achievement is assessed on relative performance,[6] the comparison set is all students in the sections that an instructor teaches (typically, 280 students in four sections) and not the students within the study group or even within the section. This implies that a student's objective is to earn the maximum score possible, regardless of the relative performance of the other members of the study group or quad.

2.2 Administrative data

The Academic Services Administration (ASA) at ISB maintains detailed records on the courses that each student enrols in, the grades achieved in these courses as well as assignment of students to study groups and residential facilities. We obtained a complete record of all enrolled students for four years from 2007-08 to 2010-11. One advantage of selecting this period was the absence of significant changes in the curriculum or administrative policies during this time.

Student assignment, coursework and grade data is supplemented with data from admissions records that contain each student's academic (GMAT scores, undergraduate and graduate institutions and associated majors), professional (sector and firm of employment, employment duration, earnings and functional role) and demographic backgrounds (year of birth, gender, marital status and citizenship). Also included is data from the on-campus job placement process. We record the earnings associated with the job offer received by students at the end of the PGP program.

Table 1 summarizes select variables from the dataset. Closely matching the BusinessWeek data, the mean GMAT score is 709. Students have an average of 4.9 years of full time work experience when they join. The average salary drawn before enrolling at ISB was Rs. 995,700 (USD 19,914)

[6]The correspondence between the class score and letter grades is not known to students during the term and determined at the end of the term.

whereas average earnings reported on graduation was Rs. 1401,100 (USD 28,202), corresponding to 41 percent increase in compensation after one year of study.[7] Seventy three percent of students are single at an average age of over 28.7 years. Twenty six percent of the students are women, and 96 percent are Indian citizens.

This combined dataset offers a number of features that makes it attractive for analyzing classroom versus roommate peer effects on the academic performance of business school students. First, the administrative source of the data allows us to map the entire set of study group and roommates for each student, and avoid potentially biased estimates due to partial sampling from the network (Chandrasekhar and Lewis 2011). Since all administrative records are mandated to be complete and truthful, self-reporting bias, measurement error and missing data do not threaten our analysis. Finally, in the one year program, attrition is negligible and student cohorts do not overlap. Therefore, non-random attrition from the sample as well as serial correlation due to overlapping peers across years are not significant concerns.[8]

The data also suffers from a few shortcomings. First, since students who conduct their own job search do not report earnings to ISB, the placement data is incomplete. If, for example, the most ambitious students or those who were unsuccessful in receiving an offer on-campus are more likely to conduct off-campus searches, this data will suffer from selection bias. Furthermore, students who conduct their own job search are most likely to rely on professional and social peers, especially off-campus networks, which implies that estimates of influence of peers on earnings at graduation will suffer from systematic biases. Finally, information on students' family characteristics such as caste, religion or parental education that are potentially important in determining educational achievement are unavailable in this data.

Nonetheless, the unique advantages of this dataset allow us to perform econometric analysis that helps uncover peer effects in student performance while at business school.

[7]Earnings were coded as zero for students who reported starting an entrepreneurial venture on graduation. At the time of writing, US $1 = Rs. 50.

[8]In the entire sample period, only 3 students joined the program but left before completion.

2.3 Assignment of study group and roommates

A unique feature of this data that makes it appropriate for analysis of peer effects is that students are simultaneously and randomly assigned into two separate and mutually exclusive sets of peers – the study group and roommates in the quad. Students in the same study group are expected to perform graded class assignments collectively with other members of the group. Students within the quad are not expected to perform any academic tasks together. To the best of our knowledge, this is the only dataset used to estimate peer effects among management students with such a feature.

Before the start of core classes, ASA assigns students to a study group, which is then assigned randomly to a section of approximately 70 students.[9] This assignment is fixed for the duration of the four core terms. Members of the study group work together to understand the coursework, as well as to complete specific group-based assignments. The share of the overall grade that is determined by group grades ranges from 0% to 50%, with 30% share in the median course. In the elective terms, students choose their own courses, which might be different from those of their study group peers.

In assigning students to study groups, ASA relies only on observable characteristics of students, following two simple sequential rules.[10] First, groups are assigned either two women, or none at all. Next, the groups are balanced in terms of the previous work experience (function and sector) of the students. Each group consists of either four or five students due to these restrictions. With these assignments, the data contains 90 study groups in the 2007-08 and 2008-09 class years, and 120 groups in the 2009-10 class year. ASA does not consider any measure potentially correlated with ability, such as GMAT score, elite undergraduate college or Master's degree while assigning students to groups, nor does ASA assign students based on any characteristic that is unobservable to the researchers such as ability, motivation or potential for interaction with peers. Hence, due to the administrative process, the assignment of individuals to groups is statistically random on

[9]The number of sections increased from six in the 2007-08 and 2008-09 class years to eight in 2009-10 as the school increased enrolment from 416 students in 2007-08 to 436 students in 2008-09 and 565 students in 2009-10 and 2010-11.

[10]One of the authors observed this process and verified that the staff member had only demographic information for each student during the assignment process.

unobservable characteristics.

In addition to the study group peers, students are also assigned to peers in the residential dormitories. Unlike many international business schools, all students at ISB are required to stay on campus in housing provided by the school throughout the length of the program. Roommates are not expected to work together on academic assignments, and involvement in each other's coursework is voluntary. Students can elect to stay in either four room quads with a shared kitchen, dining and living spaces, or in single apartments. Table 2 shows that apartments are assigned primarily to students who are married and male, since they are more likely to have cohabiting family members.[11] The variables capturing ability, such as GMAT scores, experience, earnings or a previous Master's degree, have no influence on whether a student is assigned to an apartment. Students who elect group housing are randomly assigned to quads, with two observable assignment rules. First, each quad is single sex. Second, roommates cannot overlap with study group peers. Once assigned, students stay in the same quad throughout the eight terms. Although there are more apartments than quads, most students live in quads – in the sample, 1697 out of 2281 students live in shared residences.[12]

Given the importance of random assignment in obtaining unbiased estimates, we check the effectiveness of the administrative process described above in the data. For this, we regress group mean GMAT and quad mean GMAT scores as well as the mean of last salary, experience, age, marital status and citizenship for both the study group and the quad on individual GMAT scores, including year dummies as control variables. To verify that the administrative process is also random with respect to an alternative measure of ability, we include a second set of regressions where group mean and quad mean characteristics are regressed on individual last salary. Since gender is the primary criteria for assignment of students to study groups and quads, we report results separately for women and men. Table 3 shows no statistically significant correlation between a student's GMAT score and mean group and quad characteristics. For both men and women, virtu-

[11] ISB does not solicit data on roommate preferences.

[12] Each quad is located in a "block" which consists of up to six quads. Further, each quad is located in a "student village" which consists of up to 12 blocks.

ally none of the peer characteristics are correlated with individual GMAT scores. The last salary test also reveals that earnings before joining the program are uncorrelated across groups. These results support our belief that the administrative randomization process led to the formation of study and residential groups where ability was uncorrelated within the group.

3 Empirical analysis

The objective of the empirical exercise is to investigate the role of peers on academic outcomes, separating the impact of study groups and roommates. To achieve this, we estimate a full model of the individual, study group and roommate characteristics on core term grades, with particular emphasis on heterogeneity in peer effects, and report the results. We conduct a number of robustness checks to rule out the influence of interaction costs, and variation in the size of the group work component of grades as drivers of the findings.

We select students' grade point average during core terms as the outcome measure because the study groups and the roommate assignments operate concurrently only during the core terms. We cannot use elective terms GPA or job placement outcomes (such as salary or sector of employment) since the study groups are disbanded while the roommates remain in place during elective terms and the job interviews. Hence, we cannot compare the parallel impact of the two types of peer groups on elective GPA or earnings at graduation. Online Appendix B shows that core GPA is highly correlated with earnings, suggesting that students will try to increase their grades in order to increase earnings.

3.1 Impact of study group and roommates on core terms GPA

We specify the following model to estimate the impact of study group and roommates on the academic outcomes. Given the design and structure of the experimental data as described earlier, identification of peer effects is not a significant obstacle. Although the dependent variable is theoretically truncated at 4.0 (the maximum GPA) and 0.0 (the minimum GPA), there are no

observations at these points in the data. Therefore, OLS estimates will be consistent in reporting the impact of peer characteristics on student outcomes.

$$y_{ijt} = \beta_0 + \beta_1 \mathbf{X}_{ijt} + \beta_2 \overline{\mathbf{X}}^{S}_{-ijt} + \beta_3 \mathbf{Z}^{S}_{jt} + \beta_4 \overline{\mathbf{X}}^{R}_{-ijt} + \beta_5 \mathbf{Z}^{R}_{jt} + year_t + \epsilon_{ijt} \quad (1)$$

In this specification, the outcome variable, y_{ijt} is the grade point average (GPA) from core term courses for student i in group j in cohort t. $\mathbf{X}_{ijt}$ is a vector of individual characteristics that includes the student's age, the number of years of full time experience and last salary prior to joining the program. We expect that these variables capture student maturity, experience with solving business problems and success in the corporate workplace, respectively. We also include observed demographic characteristics such as whether the student is female, single, and a citizen of India. The student's GMAT score is included as a proxy for academic ability, especially quantitative and verbal skills, among the variables in $\mathbf{X}_{ijt}$. $\overline{\mathbf{X}}^{S}_{-ijt}$ represents the mean of the same variables for study group j, excluding the characteristics of student i. Student achievement might be influenced by heterogeneity in peer characteristics, especially in ability. Therefore, we include $\mathbf{Z}^{S}_{jt}$, which captures within-group variance in study group GMAT scores, age, previous salary in Indian Rupees and years of experience. As with the group mean, the variance is calculated across all other members of group j excluding student i. $\overline{\mathbf{X}}^{R}_{-ijt}$ and $\mathbf{Z}^{R}_{jt}$ capture the corresponding group mean and variance in roommate characteristics. We include year fixed effects to control for observed and unobserved factors, such as academic policies or macroeconomic conditions, that are common for an entire cohort of students. Finally, we include an i.i.d. normal error term to account for factors such as motivation, study skills and personality that might impact a student's academic and professional outcomes, but are unobserved in the data. In this specification, the coefficients of interest are β_2, β_3, β_4 and β_5 which represent the impact of the mean and variance in study group and roommate characteristics on y_{ijt}.

Table 4 reports the results from estimation of equation (1), gradually expanding the specification to include study group and roommate characteristics. Column I of the table reports the impact of individual characteristics on individual GPA, Column II introduces study group characteristics

in mean and variance, Column III introduces roommate characteristics in mean and variance (but excluding study group variables) and finally Column IV presents the results from the full specification with all study group and roommate characteristics.

As expected, a number of individual characteristics are correlated with academic performance, including the individual's GMAT score, years of experience and salary before entering business school. In the full specification in Column IV, a student's GMAT score has a large impact on GPA, with a 100 point increase in GMAT increasing GPA by 0.291 points. This coefficient is both distinguished from the null at the 1 percent level and robust across specifications. This finding suggests that quantitative and analytical intelligence as measured by the GMAT exam is important for success in business school classes. In addition to exam scores, students with higher salaries before joining business school are also likely to earn higher grades, suggesting that professional skills and motivation to succeed in a business environment also contribute to academic success at business school. GPA decreases with greater experience (and age), perhaps reflecting the difficulty faced by more experienced students in returning to an academic environment and mastering the study skills required to earn high grades. The table also reports coefficients for a number of demographic characteristics. Women do not earn grades that are statistically different from those earned by men. Married students earn 0.066 grade points higher than unmarried students in Column IV, a result which is consistent with married workers earning more than unmarried workers (Lundberg and Rose 2000). Finally, Indian citizens have significantly higher GPAs, which may be because international students seek positions outside India where business school grades might not be used to screen candidates as strongly as in India.

The coefficients under the headings labeled "Study group (Mean)" and "Study group (Variance)" in Table 4 report the influence of the study group on student performance. The coefficients under the title "Study group (Mean)" represent β_2, the linear-in-means impact of study group peers. The coefficients under the title "Study group (Variance)" represent β_3, the impact of variance in study group characteristics on core GPA. We find that a 100 point increase in the mean GMAT score of the group is associated with a 0.03 increase in grade point average. Although this result

is not statistically significant, the coefficient suggests that the influence of mean ability of study group peers is approximately 10% of individual ability. The only coefficient under "Study group (Mean)" that can be statistically distinguished from the null is the impact of earnings before joining business school, which have a positive influence on core term grades. Under "Study group (Variance)", the coefficient for variance in GMAT scores of the study group is 0.047 in Column IV, which cannot be statistically distinguished from the null. As before, the only statistically significant variable is earnings before joining business school. The findings are robust to specification, since the coefficients in Column II and IV match qualitatively.

In contrast to the study group, the coefficients under "Roommates (Mean)" show that the linear-in-means GMAT score for roommates has a large and significant impact on student GPA. A 100-point increase in roommates' GMAT score increases student GPA by 0.108 points in Column III and 0.101 points in Column IV, a result which is significant at the 5% level. The magnitude of this effect is 35% of the impact of own GMAT score, which is larger than the effect reported by Zimmerman (2003) who found that roommates' verbal SAT score has 15% of the impact of a student's own verbal SAT score.

Importantly, we find that variance of roommates' GMAT score positively and significantly affects core terms GPA. The coefficients associated with variance of roommate GMAT are 0.154 in Column III and 0.152 in Column IV, which are both statistically significant and more than three times the magnitude of coefficient associated with variance in study group GMAT scores.[13] The presence of non-linear effects in peer influence suggests that an alternative assignment mechanism could produce welfare gains in educational output (Bhattacharya 2009).

In addition to the GMAT, we also find a consistent effect of "last salary" which reports a student's earnings prior to joining business school and represents job and industry-specific ability different from intellectual ability captured by the GMAT score. In the study group, a thousand rupee increase in mean annual earnings is associated with a 0.005 higher grade point average

[13]To ensure that the results are robust to alternative measures of dispersion in group ability, we also estimate a model where variance is replace by the absolute difference in GMAT scores of the other members of the group ($max - min$). The findings, available upon request, are consistent with those reported in Table 4.

whereas the same increase in the quad increases GPA by 0.004, which are statistically not different from each other. However, increase in variance in this measure has a significant negative impact on academic performance in both peer groups. A potential explanation for this result is that differences in earnings reflect differences in financial expectations or career goals within the group, leading to dysfunctional relationships that negatively impact academic performance.

To ensure that the results can be attributed to peers directly and do not reflect either shared (but unobserved) environmental characteristics or spurious correlations in the data, we conduct a falsification exercise where students are randomly reassigned to groups and quads in the data. We construct placebo study and residential groups by randomly shuffling the study group and quad assignment in the data. We then estimate with placebo groups. We expect that peer effects should be absent in these results and estimated coefficients associated with various peers will be both smaller in magnitude and statistically indistinguishable from the null. Table 5 does not find any discernible evidence of peer effects when estimated with the randomized groups. This falsification exercise leads to greater confidence that the estimation exercise in this section correctly identifies the impact of proximate study groups and roommates and not unobserved correlated effects.

The coefficients on both the mean and variance of roommate ability are significant, which suggests that the informal environment of the quad perhaps encourages interactive learning and students are able to learn from peers and improve grade outcomes. A second potential reason is that roommates might spend more time with each other compared to study groups, leading to greater opportunities for students to learn from each other. Finally, roommates might have greater ability to make side payments, resulting in more efficient gains from trade. For example, a roommate might promise to help with homework in return for assistance with cooking, an option that study group members do not have.

Simultaneously, the results suggest that peer ability (as measured by GMAT scores) within the study group does not significantly influence student grade outcomes. The exact reason for this finding is difficult to pinpoint and isolate since we do not have precise measures of the time and nature of students' interaction in the study group. However, we obtained information from

feedback surveys that students complete at the end of the program. In the survey, students were asked "During your ISB experience, have any issues related to diversity arisen that you would want to share?". Three students responded to this question by discussing the dynamics of their study groups. Note that these responses and our interpretations are not necessarily representative of all students.

The first student wrote that active peer learning is limited since students divide group work by specialization based on prior work experience. "In theory, there should be peer to peer learning in core term study groups. However, due to the sheer amount of work load and general emphasis on grades, work is split by expertise. Hence, for instance, the quant person works on quant while the marketing person works on marketing. Even if students want to learn from each other, the opportunity does not arise." This suggests that professional characteristics such as last salary might potentially have a larger role to play in study groups than intellectual ability as measured by the GMAT.

The second student wrote that diversity can impose interaction costs. "Too much diversity in core term study groups becomes a big issue with respect to bringing everyone's ideas to one common ground." This explanation is compatible with a negative impact of greater variance in last salary on individual GPA. If greater professional distance, as measured by variance in last salary, either makes intra-group communication difficult or increases conflict, then individual academic performance may suffer.

Finally, a third student wrote, "My core term study group experience was bad basically because of 'free-riding' by a few group mates," suggesting that students free-ride extensively on group assignments when effort is costly and the rewards are shared by all the members of the group (Holmstrom 1982). As a result, active engagement within the study group members is low, and students do not learn from higher ability peers. This may be another reason why study groups have lower impact on individual GPA compared to roommates.

3.2 Size of group incentives

Core terms GPA, the outcome variable used in the previous section, consists of a component that varies with individual performance as well as a component that varies with the study group's joint performance. The structure of the data does not allow us to separate these components, so isolating the impact of the peers on the individual component of the GPA is difficult. Nonetheless, since the analysis presented in Section 3.1 does not show that study group peers have a statistically significant influence on individual GPA, we can perhaps conclude that mechanical correlation between individual and study group performance is not likely to drive the results.

In this section, we examine the impact of the size of group incentives in different courses on the strength of peer effects.[14] We separately estimate equation (1) on three outcome variables – GPA calculated for those courses where group work constitutes either high (35% to 50%), medium (20% to 30%) or low (0% to 15%) component of the final grade.

Table 6 shows that our main finding that residential peer effects, specifically variance in roommate GMAT scores, are more salient than study group peer effects is maintained in all three specifications. In high group work courses, we also find that variance in study group GMAT scores has a positive (+0.119) and statistically significant (at the 10% level) association with own GPA. One reason for this might be that high ability peers contribute disproportionately to group output, resulting in better individual GPAs, although this explanation is difficult to verify without data on individual effort allocation in each course.

3.3 Heterogenous impact of peers

The previous section reports the impact of peers for the average student. However, the effects might be different for students who are different in terms of ability. For example, Lavy, Silva, and Weinhardt (2012) find that the presence of exceptionally high ability students has sizable positive effect on the performance of girls (but not boys) in the bottom half of the ability distribution. At the

[14]Note that the comparison between courses with a high versus low component of group work is not clean since the courses with more group work as part of the grade (typically in Strategy, Marketing, Entrepreneurship and Operations Management) are different from those with low group work (largely in Statistics, Economics and Finance).

same time, the negative effect of very weak students does not vary by student ability. Assuming that the specification for determining peer effect in the previous section yields unbiased and consistent estimates, we use it to analyze heterogeneity in the impact of formal and informal peers in more detail.[15]

We first explore the differential impact of peers on students of different ability. Students who have below mean GMAT scores might be more willing to learn from students with above average GMAT scores than vice versa. Table 7 reports the heterogeneous impact of peers on core GPA by estimating the main specification (equation 1) for students who are above and below the respective mean of either the study group ($\overline{GMAT}^S$) or the residential peers ($\overline{GMAT}^R$).[16] We find that the mean and variance of the study group's GMAT score is insignificant for both students who are above and below the mean. In contrast, the impact of variance in the residential group's GMAT score is asymmetric. The coefficient associated with students who are below the quad average is 0.308, which is significant at the 1% level, and twice the magnitude of the average effect reported in the previous section. Simultaneously, the coefficient for above mean students is very close to the null and statistically indistinguishable from it.

This result suggests that increases in peer human capital disproportionately benefits weaker group members, that stronger students are not affected by the presence of academically weaker students and that residential settings are more conducive for academic peer interaction than study groups. These empirical patterns are consistent with higher ability students transferring specific knowledge to lower ability students through, for example, direct tutoring. Our findings are consistent with studies such as Duflo, Dupas, and Kremer (2011) and Lyle (2009) who also report that relatively weaker students benefit more from high ability peers compared to stronger students.

[15] We also examine differences in peer effects over time in Online Appendix E.

[16] In an alternative specification, we estimate a model where terms representing whether a student's GMAT score is above or below the study group or quad mean are interacted with the corresponding study group and quad GMAT and added to equation 1. The results are consistent with the findings reported in Table 7 and are available upon request.

4 Conclusion

This paper investigates the impact of peers on academic outcomes using data from an elite business school in an emerging economy. We analyze the impact of peers in both study groups as well as residential settings. To overcome potential endogeneity in group formation as well as to ensure that the multiple peer groups are comparable, we exploit the random and simultaneous assignment of students to roommates and study groups in the core terms. Thus, we are able to exploit a randomized experimental design where the characteristics of the other students in the group are uncorrelated with unobserved student characteristics, yielding unbiased and consistent estimates for peer effects.

We report three main results. First, we find that roommates in residential dorms have a significantly greater impact on academic performance than the core terms study group. This suggests that social interaction is more effective in boosting academic outcomes than study groups that are designed for learning. Second, we report that core term grades are driven by heterogeneity in group ability, since variance in GMAT scores within the group has a positive and significant impact on student performance in addition to the linear-in-means measure of ability. Third, we find an asymmetric impact of the benefits of peer ability. Low ability students benefit significantly more from variance in peer GMAT scores than high ability students.

These results suggest that informal settings without expectations of joint production may be conducive to academic exchange in peer groups. In contrast, situations where students are expected to work together may suffer from classic free-riding problems that inhibit learning. This is true even among business school students who are arguably more open to, and perhaps even seek out, peer influences compared to undergraduate or secondary school students. However, we must add that these conclusions are speculative and we cannot identify the causal mechanisms by which peer effects influence academic achievement.

Our findings should be read with a few caveats. First, we do not address selection into a business career or into business school, and the impact of study group versus residential peers might be very different for individuals who are not observed in our sample. For example, students

might self-select into attending business school because they perceive the value of networking in this setting. So individuals in business careers who choose not to attend business school might be in functional roles where social or professional networks are less critical, and are therefore less motivated to interact with their peers. With a different sample, our estimates of peer effects might not be as large or as precisely estimated.

A related issue is that just because we uncovered evidence of peer effects in this setting does not imply that these findings can be readily generalized for all situations. While we argue based on institutional characteristics that the results could be representative of other graduate business programs, researchers should be cautious while extending these findings to other academic settings such as primary and secondary schools, undergraduate programs or other graduate programs. For instance, schools or undergraduate colleges might feature self-selected rather than administrator-assigned groups that allow students to create socially homogenous study groups that facilitate peer learning. Conversely, students at business schools might be strongly motivated to meet and "network" with classmates, so the strength of peer effects that we find might represent upper bounds compared to other kinds of graduate programs.

Second, while we examine academic performance, due to design and data limitations we do not estimate the impact of study group and residential peers on earnings or long term career outcomes (for example, job search, promotions and executive compensation) that might be important to business school students. Similarly, we do not report outcomes, such as the choice of major at business school or career choice afterwards, which might be influenced by a student's peers. We also do not examine whether social behavior such as academic cheating (Carrell, Malmstrom, and West 2008), smoking (Nakajima 2007) or fitness (Carrell, Hoekstra, and West 2011) is differentially affected by study group or residential peers.

Third, the paper does not outline a comprehensive model of the influence of peer effects on individual behavior. Absent a comprehensive mechanism or the ability to conduct experiments, we can neither create optimal group assignments (Bhattacharya 2009) nor evaluate the impact of specific policies (such as tracking or other ways to sort by ability) to improve student outcomes.

Nonetheless, these findings suggest that business schools and other educational institutions that wish to maximize learning should focus on out-of-classroom group activities in addition to, or as substitutes for classroom environments. Consistent with a rich literature on peer effects, these findings also suggest that group composition is important, and educational institutions should compose heterogenous groups where weaker students can learn from academically stronger peers.

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Table 1: **Summary statistics**

	Observations	**Mean**	**Std Dev.**
GMAT	1987	709	40.2
Full time experience (years)	1987	4.9	2.2
Last Salary (Rs. '000)	1835	995.7	119.5
Masters degree	1987	19.4%	39.5%
Earnings at graduation (Rs. '000)	1755	1401.1	868.9
IIT	1987	14.4%	35.1%
Delhi University	1987	15.2%	35.9%
Age (years)	1987	28.7	2.8
Single	1987	72.9%	44.4%
Female	1987	25.7%	43.7%
Citizen of India	1987	95.8%	20.1%

Notes: This table shows the summary statistics for the main dataset including students who live in single apartments. Each observation is a student, and we pool the sample over all class years from 2007-08, 2008-09, 2009-10 and 2010-11 class years. Source: ISB administrative records.

Table 2: **Allocation to single apartments**

Dependent variable: Residence in a single apartment				
	OLS		**Probit**	
	Coefficient	**Standard Error**	**Marginal effect**	**Standard Error**
GMAT	0.000	0.000	0.000	0.000
Years of experience	0.004	0.007	0.002	0.009
Last salary (Rs. '00,000s)	0.001	0.001	0.001	0.001
Masters degree	0.004	0.022	0.007	0.027
Age	0.007	0.006	0.010	0.007
Single	**-0.556*****	0.022	**-0.564*****	0.029
Female	**-0.095*****	0.019	**-0.114*****	0.020
Citizen of India	**-0.222*****	0.041	**-0.310*****	0.070
Observations	1985		1985	
R-squared	0.401		0.349	

Notes: This table examines the characteristics of students who were allocated single apartments (without roommates) at ISB. Each observation is a student, and we pool the sample over all class years from 2007-08, 2008-09, 2009-10 and 2010-11 class years. The dependent variable is 1 if the student lived in a single apartment and 0 if the student lived in a shared quad while enrolled at ISB. Both the OLS and probit regression specifications include year fixed-effects. *** implies significance at the 0.01 level, ** 0.05, * 0.10. Source: ISB administrative records.

Table 3: **Randomization check in study group and roommate assignments**

	GMAT Score		Last salary	
	Female	**Male**	**Female**	**Male**
Mean study group characteristics				
GMAT	0.066	0.004	1.965	0.317
	(0.110)	(0.058)	(4.548)	(1.381)
Last salary (Rs. '00,000s)	0.002	0.003	0.075	0.010
	(0.003)	(0.002)	(0.141)	(0.046)
Experience (years)	0.014	-0.026	0.655	**-1.011***
	(0.036)	(0.019)	(1.474)	(0.446)
Age (years)	-0.028	0.026	-1.255	0.532
	(0.033)	(0.016)	(1.361)	(0.389)
Single	0.036	-0.041	-2.014	1.473
	(0.135)	(0.064)	(5.608)	(1.514)
Citizen of India	-0.067	-0.169	-0.752	-0.556
	(0.202)	(0.114)	(8.383)	(2.724)
Mean roommate characteristics				
GMAT	-0.106	-0.054	4.975	-1.393
	(0.090)	(0.056)	(3.745)	(1.325)
Last salary (Rs. '00,000s)	0.003	-0.005	-0.043	-0.066
	(0.002)	(0.002)	(0.088)	(0.056)
Experience (years)	-0.012	-0.017	**3.750***	0.259
	(0.042)	(0.018)	(1.718)	(0.430)
Age (years)	-0.006	0.031	-1.235	-0.054
	(0.029)	(0.016)	(1.193)	(0.375)
Single	-0.019	0.110	4.266	-0.446
	(0.078)	(0.059)	(3.224)	(1.403)
Citizen of India	0.155	**0.288****	2.175	-1.161
	(0.232)	(0.097)	(9.605)	(2.318)
Observations	406	986	406	986
R-squared	0.050	0.059	0.033	0.073

Notes: This table examines the correlation between a student's GMAT score and last earnings before business school, and the mean characteristics of the study groups and roommates. The results are reported separately for sub-samples of men and women. Each observation is a student, and we pool the sample over all class years from 2007-08, 2008-09, 2009-10 and 2010-11 class years. OLS specifications include year fixed effects. Standard errors are in parentheses. *** implies significance at the 0.01 level, ** 0.05, * 0.10. Source: ISB administrative records.

Table 4: **Impact of own and peer characteristics on core terms GPA**

	(I)		(II)		(III)		(IV)	
	Coeff.	**Std error**	**Coeff.**	**Std error**	**Coeff.**	**Std error**	**Coeff.**	**Std error**
Individual characteristics								
GMAT	**0.264*****	(0.020)	**0.271*****	(0.021)	**0.290*****	(0.022)	**0.291*****	(0.022)
Last salary (Rs. '00,000s)	**0.002*****	(0.001)	**0.003*****	(0.001)	**0.004*****	(0.001)	**0.004*****	(0.001)
Experience (years)	**-0.026*****	(0.008)	**-0.025****	(0.008)	**-0.025****	(0.008)	**-0.024****	(0.008)
Age	-0.009	(0.006)	**-0.013***	(0.006)	-0.010	(0.006)	**-0.013***	(0.006)
Female	**-0.073*****	(0.017)	**-0.077*****	(0.017)	-0.119	(0.133)	-0.097	(0.133)
Single	**-0.097*****	(0.027)	**-0.100*****	(0.027)	-0.060	(0.033)	**-0.066***	(0.033)
Citizen of India	**0.168*****	(0.046)	**0.177*****	(0.045)	**0.205*****	(0.048)	**0.210*****	(0.048)
Study Group (Mean)								
GMAT			0.039	(0.044)			0.030	(0.045)
Last salary (Rs. '00,000s)			**0.006*****	(0.002)			**0.005****	(0.002)
Experience (years)			-0.008	(0.014)			-0.009	(0.014)
Age			-0.009	(0.012)			-0.011	(0.012)
Female			0.059	(0.034)			0.060	(0.035)
Single			-0.038	(0.043)			-0.046	(0.043)
Citizen of India			**0.153***	(0.073)			0.136	(0.074)
Study Group (Variance)								
GMAT			0.108	(0.058)			0.047	(0.062)
Last salary (Rs. '00,000s)			**-0.00003****	(0.00001)			**-0.00002***	(0.00001)
Experience (years)			0.001	(0.002)			0.000	(0.002)
Age			0.001	(0.001)			0.001	(0.001)
Roommates (Mean)								
GMAT					**0.108****	(0.038)	**0.101****	(0.038)
Last salary (Rs. '00,000s)					**0.005****	(0.003)	**0.004***	(0.002)
Experience (years)					-0.001	(0.013)	0.001	(0.013)
Age					-0.005	(0.010)	-0.005	(0.011)
Female					0.065	(0.134)	0.037	(0.134)
Single					**-0.082***	(0.041)	-0.075	(0.041)
Citizen of India					-0.061	(0.071)	-0.053	(0.071)
Roommates (Variance)								
GMAT					**0.154*****	(0.045)	**0.152****	(0.046)
Last salary (Rs. '00,000s)					**-0.00003*****	(0.00001)	**-0.00003****	(0.00001)
Experience (years)					-0.001	(0.003)	-0.001	(0.003)
Age					0.000	(0.002)	-0.000	(0.002)
Observations	1372		1369		1359		1357	
R-squared	0.198		0.214		0.219		0.231	

Notes: This table examines the impact of student, study group and roommate characteristics on individual grade point average. Each observation is a student, and we pool the sample over all class years from 2007-08, 2008-09, 2009-10 and 2010-11 class years. The dependent variable is each student's grade point average from 16 required courses in the one-year program. The table reports coefficients obtained from OLS estimation of equation (1). The specification includes year fixed effects. *** implies significance at the 0.01 level, ** 0.05, * 0.10. Source: ISB administrative records.

Table 5: **Randomized allocation of study groups and quads**

	Core GPA	**Term 1 GPA**	**Term 2 GPA**	**Term 3 GPA**	**Term 4 GPA**
GMAT	**0.289*** **	**0.367*** **	**0.259*** **	**0.231*** **	**0.299*** **
	(0.032)	(0.035)	(0.033)	(0.037)	(0.040)
GMAT (Mean,	-0.038	-0.060	-0.019	**-0.081***	0.007
Study group)	(0.025)	(0.030)	(0.044)	(0.035)	(0.034)
GMAT (Variance,	0.044	0.031	0.061	0.052	0.031
Study group)	(0.055)	(0.067)	(0.071)	(0.056)	(0.054)
GMAT (Mean,	0.020	0.028	0.012	-0.005	0.044
Roommates)	(0.047)	(0.059)	(0.037)	(0.050)	(0.058)
GMAT (Variance,	0.095	0.135	0.070	0.089	0.084
Roommates)	(0.063)	(0.096)	(0.048)	(0.053)	(0.070)
Observations	1381	1381	1381	1381	1381
R-squared	0.251	0.241	0.196	0.193	0.194

Notes: This table shows the impact of peer ability on student outcomes when the peers are scrambled in the data. Each observation is a student, and we pool the sample over all class years from 2007-08, 2008-09, 2009-10 and 2010-11 class years. The coefficients are obtained from OLS estimation of equation (B.1). The regression specification includes year fixed effects, as well as variables for years of experience, last salary, gender, marital status, citizenship and age in each category. Standard errors in parentheses are clustered at the student village level. *** implies significance at the 0.01 level, ** 0.05, * 0.10. Source: ISB administrative records.

Table 6: **Impact of study group and roommates GMAT scores by groupwork component in course**

	All core courses GPA	**High Groupwork**	**Medium Groupwork**	**Low Groupwork**
GMAT	**0.291*****	**0.228*****	**0.294*****	**0.388*****
	(0.022)	(0.020)	(0.026)	(0.030)
GMAT (Mean, Study group)	0.030	0.050	0.078	-0.063
	(0.045)	(0.041)	(0.052)	(0.061)
GMAT (Variance, Study group)	0.047	**0.119***	0.062	-0.065
	(0.062)	(0.057)	(0.072)	(0.084)
GMAT (Mean, Roommates)	**0.101****	**0.087***	**0.088***	**0.128***
	(0.038)	(0.035)	(0.045)	(0.052)
GMAT (Variance, Roommates)	**0.152****	**0.147*****	**0.114***	**0.196****
	(0.046)	(0.043)	(0.054)	(0.063)
Observations	1364	1364	1364	1364
R-squared	0.229	0.183	0.193	0.214

Notes: This table examines the impact of student, study group and roommate characteristics on grade point average calculated separately for courses with high, medium and low group work component of the final grade. Each observation is a student, and we pool the sample over all class years from 2007-08, 2008-09, 2009-10 and 2010-11 class years. Table reports coefficients obtained from OLS estimation of equation (1) performed for the GPA averaged over all courses, courses with high group work component of final grade (35 to 50%), courses with medium group work component of final grade (20 to 30%) and courses with low group work component of final grade (0 to 15%). Regression specification includes year fixed effects, as well as variables for years of experience, last salary, gender, marital status, citizenship and age in each category. Standard errors in parentheses. *** implies significance at the 0.01 level, ** 0.05, * 0.10. Source: ISB administrative records.

Table 7: **Heterogenous impact of peer GMAT scores**

Dependent Variable: Core terms GPA				
	$GMAT < \overline{GMAT}^S$	$GMAT > \overline{GMAT}^S$	$GMAT < \overline{GMAT}^R$	$GMAT > \overline{GMAT}^R$
GMAT	**0.347*****	**0.283*****	**0.364*****	**0.305*****
	(0.057)	(0.052)	(0.053)	(0.055)
GMAT (Mean, Study group)	-0.058	0.107		
	(0.081)	(0.072)		
GMAT (Variance, Study group)	0.233	0.035		
	(0.140)	(0.080)		
GMAT (Mean, Roommates)			0.071	0.075
			(0.068)	(0.064)
GMAT (Variance, Roommates)			**0.308*****	0.061
			(0.087)	(0.068)
Observations	1381	1381	1381	1381
R-squared	0.203	0.182	0.245	0.174

Notes: This table examines the impact of student, study group and roommate characteristics on individual grade point average. Each observation is a student, and we pool the sample over all class years from 2007-08, 2008-09, 2009-10 and 2010-11 class years. Table reports coefficients obtained from OLS estimation of equation (1) performed separately for individuals above and below respective group medians. The regression controls for year fixed effects, as well as variables for years of experience, last salary, gender, marital status, citizenship and age in each category. Standard errors in parentheses. *** implies significance at the 0.01 level, ** 0.05, * 0.10. Source: ISB administrative records.

The impact of study groups and roommates on academic performance

Tarun Jain Mudit Kapoor

Online Appendix

A ISB compared to other international business schools

Table A.1 shows that student characteristics at ISB are comparable with those at a number of leading international business schools. The mean GMAT score at ISB is 712, which is slightly below Stanford GSB (both 730) and Harvard Business School (724), comparable to Kellogg (715), Chicago Booth (715) and MIT Sloan (710), and a few points higher than INSEAD, Darden, Fuqua and LBS (703, 701, 698 and 694, respectively). The fraction of female students (28 percent) is slightly lower than the norm in other schools (35 to 38 percent). Finally, the average candidate has five years of work experience before enrolment, which is typical of many North American and European business schools. Although the Business Week data does not capture this, students arrive with wide variation in educational background and professional skills. Hence, the composition of students at ISB is arguably similar to a number of major international business schools on observable characteristics. There might be a number of factors, such as location in a developing country, which differentiate ISB from other major management schools. However, without sector-wide microdata from a large number of international schools, the impact of location, institutional or cultural factors that might be correlated with the impact of peers is difficult to estimate.

B Core terms GPA as outcome measure

We select students' grade point average during core terms as the outcome measure. However, if students' true objective is to maximize earnings, which is quite possible in a graduate business program, then academic learning as measured by core terms grades is a good outcome variable only if it is correlated with earnings. In this section, we examine the association between core terms GPA and the value of the job offered during on-campus placement, controlling for other student characteristics that might determine earnings. To do so, we specify the following OLS model for each student i in cohort t. Note that the coefficients of this model cannot be interpreted as causal estimates since we cannot rule out the impact of unobserved factors that impact both $core\_gpa_{it}$ and $earnings_{it}$.

$$log(earnings_{it}) = \delta_0 + \delta_1 core\_gpa_{it} + \delta_2 elective\_gpa_{it} + \delta_{\mathbf{3}}\mathbf{X}_{it} + year_t + \mu_{it} \tag{B.1}$$

In this model, $earnings_{it}$ is the value of the job offer reported by a student after on-campus job interviews. Although a student might receive multiple job offers, we use the salary associated with the accepted job. The coefficient of interest is δ_1 which represents the impact of a student's cumulative GPA at the end of core terms on the salary. The specification also includes a variable, $elective\_gpa_{it}$, that represents the student's grade point average in the four elective terms. The coefficients represented by $\delta_{\mathbf{3}}$ represent the impact of other professional factors, such as the GMAT score, last salary before business school, number of years of experience and a previous master's degree. We also include indicator variables for students who attend either Delhi University or Indian Institute of Technology, since the largest fraction of students attended these universities for undergraduate studies. Finally, $\mathbf{X}_{it}$ includes personal characteristics such as marital status, age, gender and citizenship status which may potentially influence professional outcomes.

Table B.1 reports the results of the estimation exercise and shows that core terms GPA is strongly correlated with salary. A one-percent increase in core terms GPA (on a scale of 0 to 4) is associated with a 1.33 percent increase in salary reported, an estimate that is statistically dif-

ferent from the null at the 10% level. This result is not surprising. In contrast to several major business schools which follow grade non-disclosure policies, ISB permits students to report their GPAs to potential employers who use this information to screen interview candidates.[1] Other characteristics that significantly influence reported salaries are GMAT and citizenship. However, since neither of these factors can be changed by a student while at ISB, these results suggest that students are strongly motivated to maximize their GPA in the core terms.

C Impact of interaction costs

In this section, we investigate the impact of varying interaction costs which can be different between study groups and roommates. Roommates co-habit the same space, and might spend many hours together every day. So even though interaction on academic matters is a choice, the cost of exercising this choice is relatively small in terms of time and effort. Conversely, members of study groups are necessarily assigned to different quads, which implies that interaction on academic matters incurs coordination costs.

While the data does not allow us to examine a setting where the interaction costs are the same for the two types of groups, we consider the impact of study group members who live very close, even if they are not in the same quad. Figure 2 shows a map of the campus with the location of the student residence clusters (SV1, SV2, SV3 and SV4) and the main academic center (AC). While the distance between clusters is 800 to 1000 feet, the distance between quads within a cluster is a few feet. Since the dataset contains information on the student cluster where each quad is located, we can calculate the number of study group members who live in the same cluster.

The following specification augments equation (1) with the number of study group members who live in the same cluster to examine the role of interaction costs for the study group.

[1] For example, see the section on education from a sample resume in Figure 1 where the candidate highlights CGPA as an important academic achievement. Anecdotal evidence suggests that consulting firms, which hire approximately one third of students, screen on the basis of GPA only, and often ignore other factors such as past work experience or specialization.

$$y_{ijt} = \gamma_0 + \gamma_1 \mathbf{X}_{ijt} + \gamma_2 \overline{\mathbf{X}}^{S}_{-ijt} + \gamma_3 \mathbf{Z}^{S}_{jt} + \gamma_4 \overline{\mathbf{X}}^{S}_{-ijt} * Same\_SV_{jt} + \gamma_5 \mathbf{Z}^{S}_{jt} * Same\_SV_{jt} + \gamma_6 \overline{\mathbf{X}}^{R}_{-ijt} + \gamma_7 \mathbf{Z}^{R}_{jt} + year_t + \epsilon_{ijt} \tag{C.1}$$

In this specification, $Same\_SV_{jt}$ is the number of members of the study group j who live in the same cluster. If all members live in the same cluster, we expect that interaction costs will be relatively low, and vice versa. Thus, if interaction costs are a significant driver of peer effects with the study group, γ_4 and γ_5 should be statistically significant.

Table C.2 reports the findings from estimation of equation (C.1). Both coefficients, γ_4 and γ_5, are very small in magnitude and statistically indistinguishable from the null. At the same time, the coefficient associated with the mean GMAT score of the study group (0.041) from this estimation is close to the one recovered from the main estimation (0.030). These findings suggest that interaction costs are not a major factor affecting study group peer effects, since reducing these does not necessarily increase the estimated impact of the study group ability on academic achievement.

D Impact of extended networks

A concern with the analysis presented in the previous sections is that the impact of the immediate peers reflects, in Manski's (**?**) words, "*correlated effects*, wherein individuals in the same group tend to behave similarly because they have similar individual characteristics or face similar institutional environments." In this case, such similar institutional environments might consist of students beyond the study group and the quad.[2]

In order to address environmental concerns, we augment equation (1) in the main paper with variables representing peers beyond the immediate study groups and roommates to check whether other students who share the same environment also influence grades. We exploit two features of the dataset. First, since the data is from an administrative source, we observe every node of the

[2]While we cannot rule out that students form networks beyond ISB, it is unlikely that these influence the outcome variable given the specific nature of material in core graduate management classes.

network. This feature allows us to map the environment for each student completely. Second, study groups are assigned to sections and roommate groups are placed in blocks randomly, with no consideration of any observed or unobserved characteristics. Thus, we modify equation (1) in the main paper to include additional variables that represent section and block characteristics to check the impact of these factors. The error term is clustered at the student village level (μ_{jt}).

$$\begin{aligned} y_{ijt} = \beta_0 + \beta_1 \mathbf{X}_{ijt} + \beta_2 \overline{\mathbf{X}}^{S}_{-ijt} + \beta_3 \mathbf{Z}^{S}_{jt} + \beta_4 \overline{\mathbf{X}}^{R}_{-ijt} + \beta_5 \mathbf{Z}^{R}_{jt} + \beta_6 \overline{\mathbf{X}}^{Sec}_{-ijt} \\ + \beta_7 \mathbf{Z}^{Sec}_{jt} + \beta_8 \overline{\mathbf{X}}^{Block}_{-ijt} + \beta_9 \mathbf{Z}^{Block}_{jt} + year_t + \mu_{jt} + \epsilon_{ijt} \end{aligned} \tag{D.1}$$

Table D.1 reports the results of this estimation. Our first finding is that addition of the section and block variables does not alter the main results reported earlier significantly. Second, while the coefficient associated with the section's mean GMAT is negative and that with the block's mean GMAT is positive, neither of these contrasting effects can be statistically indistinguishable from the null. The effect of section or block GMAT variance is also statistically insignificant. These results suggest the absence of correlated effects beyond the study group or residential quad.

E Impact of peers over terms

We next investigate the impact of study groups and roommates on a student's grade point average over each of the four core terms. Peer effects might amplify over time if students benefit from their initial interaction, or dampen if otherwise. Table E.1 reports the impact of the peer group's GMAT scores on the GPA for each core term. As expected, own GMAT score has a positive, significant and persistent impact on academic performance. The coefficient declines over the first three terms, suggesting that students who arrive with relatively weak academic preparation catch up over time. The impact of the mean study group GMAT score is negative in the first term, although statistically insignificant. This offers a potential explanation why the coefficient on mean study group GMAT score is persistently small and insignificant. If initial interactions within the group do not enhance

learning, for example, due to a extensive free-riding problems, then the study group ceases to be the setting for positive interactions. Instead, the coefficients on roommate GMAT scores are consistently positive and significant, suggesting that students interact mainly in the quad.

Table E.2 reports the impact of core-term study groups and roommates on elective terms grade point average. In the elective terms, students continue with the same set of roommates, but the core-term study groups are disbanded and groups are self-selected in all courses. Thus, the coefficients represent the persistent and concurrent impact of roommates, but only the persistent impact of study group members. The results indicate that roommates continue to influence academic performance even when all students are not taking the same set of courses. However, none of the characteristics of the core-term study groups are statistically significant, indicating that these groups do not have a persistent impact. This is not surprising. If the study group did not influence students' grades when the group was required to work together, it is unlikely to do so once this requirement is removed.

Table A.1: **Indian School of Business compared to major international business schools**

	GMAT (Mean)	**Years of work experience**	**Female (Fraction)**	**Class size**
Stanford GSB	730	4.1	34%	401
Harvard Business School	724	4.0	39%	901
Wharton (UPenn)	720	6	36%	823
Kellogg (Northwestern)	715	5	35%	475
Booth (UChicago)	715	4.6	35%	1177
IIM Ahmedabad PGPX	713	10	7%	86
Indian School of Business	**712**	**4.9**	**28%**	**560**
MIT Sloan	710	5	35%	396
INSEAD	703	6	33%	988
Darden (University of Virginia)	701	4.7	29%	328
Fuqua (Duke)	698	5.0	37%	887
London Business School	694	5.6	25%	319

Note: This table reports summary characteristics of students enroled at select international business schools. The data is for the Class of 2011 for the full time MBA programs (or equivalent) for all schools. Source: School websites and `http://www.businessweek.com`.

Table B.1: **Determinants of earnings at graduation**

Dependent variable: Log of value of on-campus offer		
	Coefficient	**Std. error**
Core terms GPA	**1.328***	(0.603)
Elective terms GPA	0.198	(0.597)
GMAT	**1.036****	(0.353)
Years of experience	-0.015	(0.113)
Last salary (Rs. '000s)	-0.011	(0.011)
Masters degree	-0.088	(0.347)
IIT	0.150	(0.386)
Delhi University	-0.073	(0.355)
Female	0.522	(0.302)
Single	0.336	(0.348)
Citizen of India	**3.34*****	(0.692)
Age (in years)	0.030	(0.098)
Observations	1603	
R-squared	0.175	

Notes: This table reports the correlation of individual characteristics with the log of earnings associated with the accepted job obtained through the on-campus placement office. Each observation is a student, and we pool the sample over all class years from 2007-08, 2008-09, 2009-10 and 2010-11 class years. The table reports coefficients obtained from OLS estimation of equation (B.1). The regression controls for year fixed effects. *** implies significance at the 0.01 level, ** 0.05, * 0.10. Source: ISB administrative records.

EDUCATION

Indian School of Business **April 2009–to date**

Post Graduate Program in Management (Major- Finance & Marketing)

- **CGPA: 3.59/4.0 (Top 16%)**; GMAT: 760/800 (99 percentile)
- Developing the growth strategy for Staples-Future Group JV to achieve 40% growth in revenues through the retail channel
  - Designed the Customer Acquisition and Retention programme to be implemented across stores nationwide
  - Carried out extensive market and competitor analysis to come up with a new sales and operations model
- Undertook a consulting engagement with ISB Operations and Marketing teams to redesign the ISB Merchandize Store
  - Project being implemented for Solstice'09- annual ISB alumni meet
- Working on a Research Project on the transformation of State Bank of India through Business Process Re-engineering

Indian Institute of Technology, Kanpur **May 2002-May 2006**

Bachelor of Technology (B.Tech), Electrical Engineering

- **CGPA: 8.4/10;** Among the **top 0.1%** in IIT Joint Entrance Exam (All India Rank 255)
- Summer Training at ITC Ltd.: Designed a benchmark cigarette factory based on Lean manufacturing principles (Capex proposal of $23 million). Project adjudged among the top 3 projects (from 20+ projects) in the division

Delhi Public School, R.K. Puram **April 2001- March 2002**

- Secured **93.2%** in CBSE, AISSCE; **Ranked 7/889** in school; Awarded National CBSE Merit Scholarship and Gold Medal

Figure 1: **Sample resume**

Notes: This figure shows a sample resume on record at the the on-campus placement office. Source: ISB administrative records.

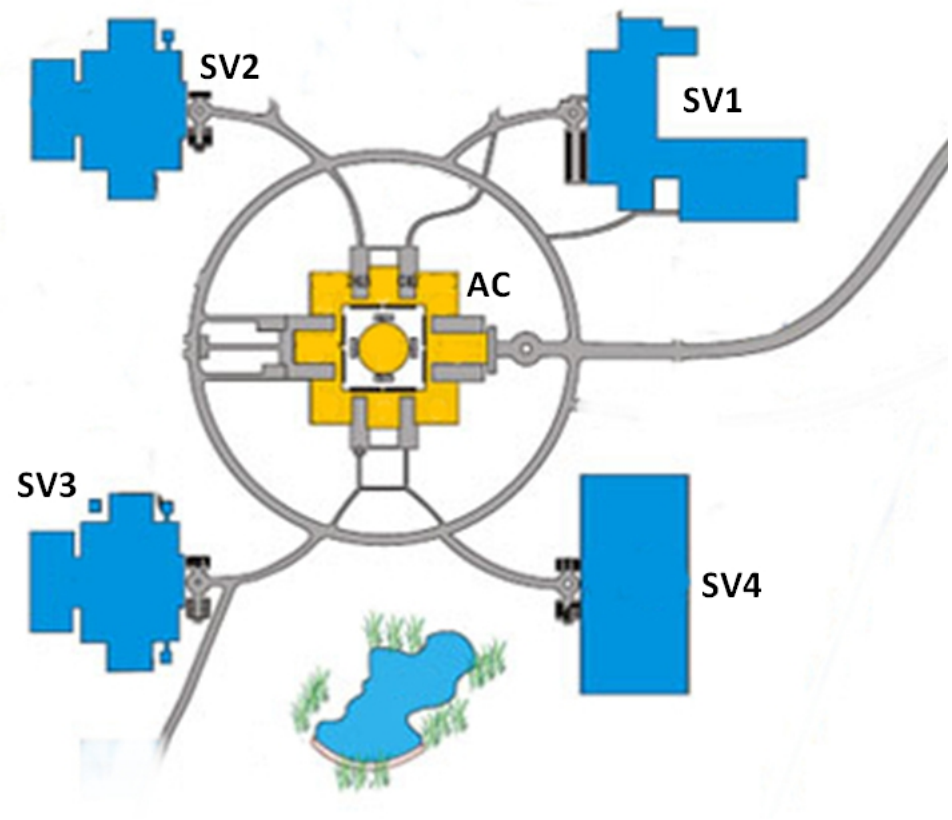

Figure 2: **Map of ISB campus with location of Student Villages and Academic Center**

Notes: This figure shows the student resident clusters ("villages") which are marked SV1, SV2, SV3 and SV3. The distance between adjacent clusters is 800 feet. Classes are held in the main academic center (AC) which also contains space for student meetings. Source: `http://www.isb.edu`.

Table C.2: **Impact of geographically close study group members**

Dependent Variable: Core terms GPA		
	Coefficient	**(Std error)**
GMAT	**0.292*** **	(0.022)
GMAT (Mean, Study group)	0.041	(0.047)
GMAT (Variance, Study group)	0.069	(0.132)
GMAT (Mean, Study group) x No. of study group members in same SV	-0.004	(0.006)
GMAT (Variance, Study group) x No. of study group members in same SV	-0.010	(0.052)
GMAT (Mean, Roommates)	**0.100** **	(0.038)
GMAT (Variance, Roommates)	**0.151** **	(0.046)
Observations	1364	
R-squared	0.233	

Notes: This table examines the impact of study group members who live in the same student village on individual grade point average. Each observation is a student, and we pool the sample over all class years from 2007-08, 2008-09, 2009-10 and 2010-11 class years. The table reports OLS coefficients obtained from estimation of equation (C.1). The regression specification includes year fixed effects, as well as variables for years of experience, last salary, gender, marital status, citizenship and age in each category. Standard errors in parentheses. *** implies significance at the 0.01 level, ** 0.05, * 0.10. Source: ISB administrative records.

Table D.1: **Impact of extended networks**

	Core GPA	**Term 1 GPA**	**Term 2 GPA**	**Term 3 GPA**	**Term 4 GPA**
GMAT	**0.293*****	**0.367*****	**0.247*****	**0.231*****	**0.324*****
	(0.031)	(0.043)	(0.032)	(0.022)	(0.037)
GMAT (Mean, Study group)	0.048	-0.016	0.092	0.084	0.038
	(0.054)	(0.088)	(0.049)	(0.056)	(0.055)
GMAT (Variance, Study group)	0.050	-0.012	0.077	0.087	0.052
	(0.067)	(0.105)	(0.060)	(0.085)	(0.057)
GMAT (Mean, Section)	**-0.433***	-0.224	-0.208	**-0.857****	-0.451
	(0.168)	(0.177)	(0.172)	(0.233)	(0.340)
GMAT (Variance, Section)	-0.075	0.391	0.024	**-0.701***	-0.028
	(0.213)	(0.272)	(0.220)	(0.324)	(0.385)
GMAT (Mean, Roommates)	**0.096***	0.081	**0.104***	0.077	**0.125***
	(0.039)	(0.055)	(0.043)	(0.050)	(0.043)
GMAT (Variance, Roommates)	**0.171*****	**0.204*****	**0.117***	**0.139****	**0.220*****
	(0.033)	(0.042)	(0.046)	(0.044)	(0.048)
GMAT (Mean, Block peers)	0.061	0.108	0.069	0.035	0.024
	(0.104)	(0.133)	(0.113)	(0.107)	(0.124)
GMAT (Variance, Block peers)	-0.047	-0.008	0.019	-0.016	**-0.180***
	(0.072)	(0.095)	(0.126)	(0.081)	(0.064)
Observations	1381	1381	1381	1381	1381
R-squared	0.238	0.236	0.192	0.173	0.190

Notes: This table examines the impact of students who are in the same class section or live in the same residential block on individual grade point average. Each observation is a student, and we pool the sample over all class years from 2007-08, 2008-09, 2009-10 and 2010-11 class years. The table reports coefficients obtained from OLS estimation of equation (D.1). The regression specification includes year fixed effects, as well as variables for years of experience, last salary, gender, marital status, citizenship and age in each category. Standard errors in parentheses are clustered at the student village level. *** implies significance at the 0.01 level, ** 0.05, * 0.10. Source: ISB administrative records.

Table E.1: **Impact of GMAT scores over terms**

	Core GPA	**Term 1 GPA**	**Term 2 GPA**	**Term 3 GPA**	**Term 4 GPA**
GMAT	**0.291***** (0.022)	**0.365***** (0.029)	**0.246***** (0.023)	**0.231***** (0.025)	**0.319***** (0.025)
GMAT (Mean, Study group)	0.030 (0.045)	-0.019 (0.059)	0.081 (0.047)	0.049 (0.052)	0.014 (0.051)
GMAT (Variance, Study group)	0.047 (0.062)	0.009 (0.082)	0.076 (0.065)	0.061 (0.072)	0.044 (0.071)
GMAT (Mean, Roommates)	**0.101**** (0.038)	**0.103*** (0.050)	**0.108**** (0.040)	0.0763 (0.044)	**0.117**** (0.043)
GMAT (Variance, Roommates)	**0.152**** (0.046)	**0.193**** (0.061)	**0.127**** (0.049)	**0.121*** (0.054)	**0.163**** (0.053)
Observations	1357	1357	1357	1357	1357
R-squared	0.231	0.227	0.185	0.159	0.176

Notes: This table examines the impact of study groups and roommates on individual grade point average in each of the four core terms. Each observation is a student, and we pool the sample over all class years from 2007-08, 2008-09, 2009-10 and 2010-11 class years. Table reports coefficients obtained from OLS estimation of equation (**??**). Regression specification includes year fixed effects, as well as variables for years of experience, last salary, gender, marital status, citizenship and age in each category. Standard errors in parentheses. *** implies significance at the 0.01 level, ** 0.05, * 0.10. Source: ISB administrative records.

Table E.2: **Impact of peers on elective terms GPA**

	A: Core GPA		**B: Elective GPA**	
	Coeff.	**Std Err.**	**Coeff.**	**Std Err.**
Individual characteristics				
GMAT	**0.291*****	(0.022)	**0.149*****	(0.022)
Last salary (Rs. '00,000s)	**0.004*****	(0.001)	**0.003****	(0.001)
Experience (years)	**-0.024****	(0.008)	-0.008	(0.008)
Study Group (Mean)				
GMAT	0.030	(0.045)	0.010	(0.045)
Last salary (Rs. '00,000s)	**0.005****	(0.002)	0.002	(0.002)
Experience (years)	-0.009	(0.014)	0.021	(0.014)
Study Group (Variance)				
GMAT	0.047	(0.062)	0.023	(0.062)
Last salary (Rs. '00,000s)	**-0.00002***	(0.00001)	-0.00002	(0.00001)
Experience (years)	0.000	(0.002)	-0.003	(0.002)
Roommates (Mean)				
GMAT	**0.101****	(0.038)	**0.110****	(0.038)
Last salary (Rs. '00,000s)	**0.004***	(0.002)	0.001	(0.002)
Experience (years)	0.001	(0.013)	0.001	(0.013)
Roommates (Variance)				
GMAT	**0.152****	(0.046)	**0.091***	(0.046)
Last salary (Rs. '00,000s)	**-0.00003****	(0.00001)	-0.000005	(0.000009)
Experience (years)	-0.001	(0.003)	0.002	(0.003)
Observations	1357		1357	
R-squared	0.231		0.069	

Notes: This table examines the impact of study groups and roommates on individual grade point average separately for required core terms and elective terms. Each observation is a student, and we pool the sample over all class years from 2007-08, 2008-09, 2009-10 and 2010-11 class years. The table reports coefficients obtained from OLS estimation of equation (1) in the main paper. The specification includes year fixed effects, as well as variables for gender, marital status, citizenship and age in each category. *** implies significance at the 0.01 level, **0.05, *0.10. Source: ISB administrative records.