What can be learned about peer effects using college roommates?

Evidence from new survey data and students from disadvantaged backgrounds

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Abstract:
Previous papers which examine the importance of peer effects using exogenous variation in college roommates have found only very limited evidence that a student's first year grade performance is influenced by the observable academic characteristics of his/her roommate. One possible explanation for this finding is that peer effects do not play a particularly important role in the higher education setting. However, another very plausible explanation for this finding is that peer effects are important in higher education but that these previous empirical efforts have simply not been "looking in the right place" to find the evidence of peer effects in this setting. Thus, while these papers have received considerable attention due to the general difficulty of finding credible exogenous variation in peer quality, they have difficulty answering the most fundamental question related to peer effects in this higher education - whether peer effects play an important role or not. This paper provides depth to the peer effects literature using unique new survey and administrative data.

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Peer effects have the potential to play important roles in determining the impact of many current and potential education policies. Unfortunately, determining the nature and importance of peer effects in either lower or higher education is a difficult task. The empirical difficulty stems from the reality that a given student's classmates and friends are determined by a complex set of decisions made by the student, the student's parents, and/or school administrators and teachers. This non-randomness creates problems of inference because it implies that unobservable determinants of a particular student's academic outcomes may tend to be systematically related to the observable and unobservable characteristics of his/her friends or classmates.

This empirical difficulty was emphasized recently by Sacerdote (2001) and Zimmerman (2003) who reviewed past literature on peer effects and proposed a way to obtain information about the importance of peer effects.[1] Specifically, the authors suggested that a student's first year college roommate has a potentially important influence on the student's first year college experience and outcomes. Thus, if the housing assignment process is such that these peers are randomly assigned or are randomly assigned conditional on information that is known to the researcher, the relationship between the college outcomes of students and the characteristics of their roommates represents a causal impact of peers that is not clouded by the problematic bias that may be present when students' peers are endogenously determined. In terms of academic outcomes, Sacerdote and Zimmerman examined the relationship between a student's first-year college grade point average and certain observable academic characteristics of his/her roommate.

These papers find only very limited evidence that a student's first year grade performance is influenced by the observable academic characteristics of his/her roommate.[2,3] One possible explanation for

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[1]The authors present a review of past theoretical and empirical work on peer effects. Given the thoroughness of the review, we have chosen not to repeat it here.

[2]Sacerdote (2001) finds no evidence that a student's first year grade point average is influenced by his/her roommate's score on an academic index created by the Dartmouth admissions office if this score is included in the specified grade regression in a linear fashion. In a different specification, having a roommate with an academic index score in the top 25% is found to increase a student's grade point average by .033 relative to having a roommate with a score in the bottom 25% and by .047 relative to having a roommate with a score in the middle 50%. A test of the null hypothesis that there is no difference between having a roommate in the top 25% and having a roommate in the bottom 25% is not rejected at standard significance levels. A test of the null hypothesis that there

this finding is that peer effects do not play a particularly important role in higher education. However, another very plausible explanation for this finding is that peer effects are important in higher education but that these previous empirical efforts have simply not been "looking in the right place" to find the evidence of peer effects. Thus, while these papers have received considerable attention due to the general difficulty of finding credible exogenous variation in peer quality, they have difficulty answering the most fundamental question related to peer effects in higher education - whether peer effects play an important role or not.[4]

In this paper we provide new information about this issue which both allows us to provide new information about the importance of peer effects and serves as a complement to the earlier work by Sacerdote and Zimmerman by providing guidance for interpreting their results. Our approach involves both thinking carefully and providing empirical evidence about the reasons that previous studies may have not been "looking in the right place" to find evidence of peer effects. There are several very plausible and interrelated reasons that this may be the case. First, it is not clear that previous studies have been looking at the performance of the types of students who would benefit substantially from peers. While policy interest in peer effects typically arises in contexts where some of the students of interest are of low ability or are from disadvantaged backgrounds, virtually all students at Dartmouth College and Williams College which are studied by Sacerdote (2001) and Zimmerman (2003) respectively are of very high quality.[5] The reality that

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is no difference between a roommate in the top 25% and a roommate in the middle 50% yields a t-statistic of 1.81.

[3]Zimmerman (2003) finds no evidence that a student's first year grade point average is influenced by his/her roommate's total Scholastic Aptitude Test (SAT) score. He finds evidence that a student's first year grades are positively correlated with his/her roommate's verbal SAT score if the roommate's math SAT score is also included in the regression specification. However, the estimated effect of math SAT scores is negative and the paper does not provide direct evidence of whether students benefit from having roommates with higher verbal SAT scores after taking into account that, on average, these students also are likely to have higher math SAT scores.

[4] The difficulty of providing credible evidence about peer effects has been well-recognized. As some evidence of this reality, despite the fact that the papers of Sacerdote and Zimmerman have difficulty providing much information about whether peer effects play an important role or not in higher education, Hoxby (2000) writes, "Some of the most convincing estimates of peer effects come from policy or natural experiments at the college or neighborhood level. For instance, Zimmerman and Sacerdote estimate the effects of college roommates who are conditionally randomly assigned at Williams College and Dartmouth College, respectively."

[5]It was very natural for the authors to study these schools because they had important knowledge about institutional details. However, Dartmouth College is the 6th or 7th most selective undergraduate school in the U.S.

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virtually all entering students at Dartmouth and Williams are likely to arrive at school with strong academic ability, good study habits, and strong beliefs about the importance of college may substantially mitigate the potential influence of peer effects.[6]

Second, even if a student at the types of schools being studied would benefit substantially from good peers, it is not clear that a student's randomly assigned roommate represents a peer of "potential influence." From a theoretical standpoint, it is not immediately obvious what type of relationship should be expected between individuals who are randomly assigned to the same room as freshmen. On one hand, the roommates may spend a substantial amount of time together out of necessity or because the "forced" interaction between them leads to an actual friendship. On the other hand, if indeed the roommate is randomly drawn from the distribution of freshmen at the school, a student may find that there are many other students at the school who have more compatible interests and preferences than his/her roommate. Unfortunately, there exists very little direct empirical evidence on the process by which individuals choose friends while in school, and, as a result, very little evidence exists about whether it makes sense to examine freshmen roommates if one is interested in looking for evidence of peer effects.

Finally, even if a student at these schools would benefit substantially from the presence of good peers and the roommate represents a peer of potential influence, it is not clear that previous studies have successfully pinpointed the observable characteristics of roommates that are most likely to be related to peer "quality" in this context. An important point that has not been discussed in these previous papers is that roommate peer effect studies, by necessity, focus on academic outcomes that are by and large short-term in nature. In the short run it seems likely that a student's academic ability is to a large extent fixed but that a student's decisions about time-use and study habits can be influenced. This suggests that the primary avenue

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based on college entrance exam scores and high school rank. The average combined SAT score at Williams College places the average student in the top 10% of the population of test takers and the average combined SAT score of students in the lowest 15% of the Williams class would be at about the 75th percentile in the population.

[6]This possibility is one of the primary motivating factors for the recent work of Foster (2003) who examines students at the University of Maryland.

through which first-year college roommates can serve as good peers is by acting as positive role models and by encouraging conscientious study habits and effort. Thus, if variation in a particular observable characteristic tends to primarily capture differences in academic ability per se rather than whether a person has habits or beliefs that would make him/her a good role model, then perhaps we should not expect a strong relationship between college grades and that observable characteristic of roommates. In addition to being helpful for understanding what observable characteristics are most likely to be related to peer quality, this type of simple theory/intuition, which has not generally received attention in previous work, is also a necessity for understanding what we might be able to learn, and perhaps more importantly, what we will not be able to learn about peer effects more generally using roommate studies.[7] This is important given that the college roommate context is one of very few sources of credible exogenous variation that can be used to get a sense of the importance of peer effects.

The approach we take in this paper involves a serious consideration of the three reasons described above. Our ability to provide depth to the existing literature is made possible by unique data from Berea College which is located in central Kentucky where the "Bluegrass meets the foothills of the Appalachian Mountains." The unique features of the data are introduced in Section II with additional detail provided in the subsequent sections of the paper. With respect to the first reason discussed above, a descriptive view of students indicates that students at Berea are often of the type that policy discussion has suggested might benefit the most from having good peers. In Section III, we provide information about the second reason discussed above by taking advantage of unique survey data to explore the relationship between students and their randomly assigned roommates. Roughly speaking, we find that it seems reasonable to think of randomly assigned roommates as peers of "potential influence," although there is some evidence that some of the

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[7]Differences between higher education and other educational contexts where peer effects may be of interest clearly makes it undesirable to draw specific conclusions about peer effects in the latter using evidence about peer effects in the former. Nonetheless, given the difficulty of finding credible evidence of the importance of peer effects in other contexts, it seems worthwhile to think carefully about whether or not roommate studies can be suggestive of the extent to which peer effects may generally be important. This requires understanding why we should or should not expect to find peer effects in roommate studies and through what avenues peer effects might arise.

substantial interactions between roommates occur out of necessity rather than because the roommates have become good friends. Section IV is motivated by the third reason discussed above. We begin by discussing in more detail the avenues through which it seems logical that roommates might make good peers in this particular educational context. Our discussion, taken together with an examination of both unique survey data about the *academic* interactions between randomly assigned roommates and unique survey data on student time-use, provides guidance about which observable characteristics would most plausibly be related to peer quality at this school and suggests that, at least at Berea, it would not be particularly informative to look for evidence of peer effects using the types of measures used in past work.

In Section V we examine whether we can find evidence of peer effects at Berea. We find evidence using the types of roommate characteristics that our simple intuition/theory and empirical work in Section IV suggest are more likely to be related to peer quality. We find differences in the importance of peer effects by sex and, using our unique survey data, are able to provide empirical evidence for why these differences exist. Section VI concludes.

II.   Berea College, Data, and the Roommate Assignment Process

Our analysis involves both the use of administrative data from the period 1991-1996 and unique survey data from the years 2000-2001. In the next two subsections we describe how we use the data from each period and our rationale for these uses, describe the housing assignment process at Berea, and provide a descriptive view of students at Berea.

II.1 Administrative data from the period 1991-1996

In Section V, where we look for evidence of a relationship between a student's outcomes and the characteristics of his/her roommate, we use administrative data for a sample of 1295 students who entered Berea College as freshmen between 1991 and 1996. Our rationale for using these data for this purpose is that the roommate assignment process was unconditionally random during this period. Specifically, during this period incoming freshmen at Berea were not asked to complete a housing preference questionnaire and

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were simply placed in available rooms without reference to preferences, backgrounds, or academic ability.[8] Nonetheless, given the importance of the randomness in this application, we provide indirect evidence in Section V to support this belief that the process is indeed random.

Descriptive statistics for this sample are shown in Table 1. Berea operates under a mission of providing educational opportunities to those of "great promise but limited economic resources." The INCOME entry in Table 1, defined as the family income of a student divided by $10,000, indicates that students at Berea tend to be economically disadvantaged with an average family income of slightly more than $21,000. Twenty-five percent of the students in our sample come from families with income of less than $11,400. The wealthiest twenty-five percent of the students in our sample come from families with income of greater than $30,700 and less than approximately $70,000.

The majority of students at Berea take the American College Test (ACT), and, when necessary, we convert Scholastic Aptitude Test (SAT) scores to ACT equivalents. In the remainder of the paper we use combined math and verbal ACT scores, but we have found essentially no difference in the results when ACT math and verbal scores are included separately in the empirical work. The 10th percentile, median, and 90th percentile for verbal ACT scores at Berea are 17, 22, and 28 respectively which correspond roughly to the 31st, 65th, and 92nd percentiles of all ACT test takers. The 10th percentile, median, and 90th percentile for math ACT scores at Berea are 16, 22, and 26 respectively which correspond roughly to the 22nd, 66st, and 85th percentiles of all ACT test takers. Table 1 also indicates a large amount of variation in high school grade point averages (HSGPA). We note that high school grades are missing for approximately 25% of our sample.

To be consistent with other work we concentrate primarily on grade outcomes, but, in addition, also mention results for a retention outcome. The grade outcome that we focus on is a person's first semester

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[8]There seems to be a belief at Berea that housing preference questions are limited in usefulness due to misreporting of behaviors such as smoking. As evidence of the school's intention to randomly assign rooms, in at least one year roommates were assigned using a random assignment software that exists on the campus computer system.

grade point average (G). The retention outcome we examine is whether the student stays in school at least until the beginning of his/her second year. Table 1 shows a large degree of variation in these outcomes. The average first semester grade point average for all students is 2.47 with a standard deviation of .874.[9] Only .68 of all students return to Berea for their second year.

Thus, the descriptive view of students at Berea suggests that, in terms of both academic/family background and college outcomes, students at Berea tend to be much different than those used in the previous work of Sacerdote and Zimmerman and are much more likely to be of the type that policy discussion has suggested might benefit the most from having good peers.

II.2 Survey Data from the Berea Panel Study for 2001-2002

In Section III, where we examine the interactions between students and their randomly assigned roommates, and in Section IV, where we look for theoretical and empirical guidance about the type of characteristics that might be related to peer quality, we use data for students who entered Berea in the fall semesters of 2000 and 2001. Our rationale for this is that unique survey data is available for these students from the Berea Panel Study (BPS).

Todd Stinebrickner and Ralph Stinebrickner (hereafter referred to as S&S) began the Berea Panel Study (BPS) with the explicit objective of collecting the type of detailed information that is necessary to provide a comprehensive view of the decision-making process of college students. Two cohorts were chosen with baseline surveys being administered to the first BPS cohort (the 2000 cohort) immediately before it began its freshman year in the fall of 2000 and baseline surveys being administered to the second BPS cohort (the 2001 cohort) immediately before it began its freshman year in the fall of 2001. In addition to collecting detailed background information about students and their families, the baseline surveys were designed to take advantage of recent advances in survey methodology in order to collect information about students'

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[9]The mean (standard deviation) of first year GPA at Dartmouth is 3.20 (.43). The mean (standard deviation) of first semester GPA at Williams is 3.10 (.510).

preferences and expectations towards uncertain future events and outcomes (e.g., academic performance, labor market outcomes, non-pecuniary benefits of school, marriage and children) that could influence decisions. Substantial follow-up surveys that are administered at the beginning and end of each subsequent semester have been designed to document the experiences of students and how various factors that might influence decisions change over time.

Of direct relevance to our analysis of Section III, which examines whether a roommate represents a peer of "potential influence," the follow-up surveys elicit information about a student's overall interactions and academic interactions with his/her roommate and his/her other friends. Of direct relevance to our analysis in Section IV, which examines what characteristics might be expected to be related to peer quality, a sequence of shorter surveys that are administered at multiple times each year have been designed to provide information about how students are using their time.

It is worth noting that, while it would be desirable to also use the data from the BPS sample period to look for evidence of peer effects in Section V, doing so is not feasible for reasons related to sample size. While roommates were unconditionally randomly assigned during the 1991-1996 period, an institutional change that took place after that period implies that not all roommates have been randomly assigned after that period. In particular, the college introduced a freshman orientation session that is held in the summer before college entrance and also allowed students the option of requesting roommates for their freshmen year. Approximately one-third of entering students now request a roommate. For freshmen who enter Berea during the 2000 and 2001 academic years we are able to identify which students did not request roommates using a question in our BPS survey. We use these students, who were randomly assigned a roommate, in our empirical work in Section IV. However, while this subset is large enough for our purposes of Section IV, it is too small for the purposes of Section V where we look for evidence of peer effects.   As a result, we use the data from the earlier period for that analysis.

III. Are roommates peers of "potential influence?"

As discussed in the introduction, uncertainty about the relevance of the three reasons that previous studies may not have been looking in the "right place" for evidence of peer effects makes it difficult to interpret the lack of strong evidence that exists in these previous studies. In this section we examine the second of the three reasons - that students may not have substantial relationships with their first year roommates. As discussed in the introduction, this possibility is not ruled out by theory and virtually no empirical evidence currently exists about this issue.

To examine whether roommates are peers of "potential influence" we turn to data from the Berea Panel Study. For reasons related to the specifics of the survey instruments that were used, we focus on the second (2001) BPS cohort. For this cohort 375 out of 420 (.89) eligible students completed the baseline BPS survey which was a necessary condition for continued involvement in the survey. Of these 375 participants, 320 students (.85) answered a question in November (Question O in the Appendix) which elicits direct evidence about a student's interactions with his/her roommate and other friends. Ten of these students did not have roommates. Of the remaining 310 students, 204 did not request a roommate and were randomly assigned a roommate by the school.

The information collected in the second column of Question O in the Appendix provides evidence that students do have substantial interactions with their first year roommates. For example, on average, a student spends 21.66 hours per week with his/her roommate and 21.28 hours per week with the non-roommate that he/she spends the most time with. Forty-seven percent of students spend more time with their roommate than any other friend. At the same time, the data also suggest that some of the time spent with roommates is out of necessity. While seventy-two percent of students spend more time with their roommate than at least one of their three best (non-roommate) friends, only thirty-seven percent of students list their roommate as one of their best four friends. Thus, while the evidence suggests that it is reasonable to think of a roommate as a peer of "potential influence," as discussed in detail in the next section, it also highlights the importance of thinking carefully about the avenues through which peer effects might be expected to arise.

IV. What observable characteristics might be related to peer quality in this context?

A second possible reason that previous studies may not have been looking in the right place for evidence of peer effect is that these studies may not have pinpointed observable characteristics that are most plausibly related to peer quality at the particular schools being studied. In this section, we discuss the avenues through which peers effects are likely to operate in this particular context, and, given this discussion, provide some empirical evidence that is relevant for understanding what observable characteristics might be expected to be related to peer quality at this school.

There are two primary avenues through which peer effects might operate in educational contexts. First, good peers could have the effect of increasing the amount of academic material that a student can comprehend at a given effort level. Defining academic "ability" to capture both a student's innate raw intelligence and also his academic preparation at a particular point in school, this avenue could be relevant if, for example, interacting with high ability peers about the topics being covered in courses helps a low ability student understand course material more efficiently.[10] Second, good peers could have the effect of changing a student's decisions about how much effort to put into his classes or could have the effect of changing a student's decisions about how much (or what type) of education to obtain conditional on a particular academic performance.

In understanding the plausibility of the first avenue in this particular educational context, it seems especially important to recognize that the freshmen outcomes in the roommate literature occur relatively quickly after a student receives the "treatment" of being assigned a roommate, and, as a result, are essentially short-run in nature.[11] While the capacity of the high ability student to comprehend new material or

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[10]The students could be helped directly with their coursework by other students or could benefit from hearing insight of other students in classroom discussion. In certain educational contexts, this avenue could also be of importance if the existence of certain types of peers influences the amount of attention that a student receives from a teacher or if the parents of particular types of students influence the quality of the school through financial or non-financial means.

[11]The necessity of examining first year outcomes occurs because roommates are not randomly assigned after this point.

solve/analyze academic problems/questions could perhaps eventually be transmitted to some extent to the low ability student, the reality that academic ability (as defined above) has been determined in this context both by raw intelligence and by eighteen years of formal and informal schooling that takes place before a student arrives at college seems to suggest that these types of ability skills will be largely fixed in the short run.

At the very least, this avenue would only seem to be relevant if a student spends a very substantial amount of time interacting with his/her roommate on academic matters. In practice, it seems far from certain that we should expect this to be the case. Even if a high ability roommate is generally open to helping his/her low ability roommate understand the specifics of his coursework, in practice it may be quite costly for him to do so given that it is likely that the two students will not be taking the same courses. The evidence in the previous section that students spend substantial amounts of time with their roommates but often do not view their roommates as one of their four best friends raises some doubt about whether students would be willing to pay this cost to help a roommate in this fashion. In addition, the BPS allows us to provide direct evidence about the importance of this issue using the information from column 3 of question O in the Appendix. We find that the median student spends only approximately 20 minutes a day "studying/talking about classes" with his/her roommate. Given this relatively small number and the reality that some of these reported minutes almost certainly involve time spent studying separately in the same dorm room without actually interacting on academic matters, the discussion and evidence suggests that this first avenue is not likely to be particularly important in this particular educational context.

However, in contrast, it seems quite plausible that the second avenue might be important. S&S (2003b) and S&S (2004) suggest that time-use in general and study-effort more specifically play very important roles in determining grade outcomes. Further, it seems likely that at very little cost to himself/herself, a person who has conscientious study habits or strong beliefs about the importance of educational attainment could serve as a positive role model. Thus, if the presence of this type of role model influences a roommate's decisions about time-use or views about the importance of educational attainment, this second avenue could be of importance.

Thus, the previous discussion together with evidence that the academic interactions between roommates is rather limited suggests that, if one is interested in determining whether peer effects are important in this context, it makes sense to look for evidence in roommate characteristics that are related to what kind of a role model a roommate might make rather than roommate characteristics that measure academic ability per se. In particular, given that time-use is a characteristic of role models that is readily observable by roommates, it seems logical to think about roommate characteristics that are related to time-use.

Unfortunately, in general it is difficult to know which observable roommate characteristics are related to a person's time-use behavior. For example, as discussed in S&S(2004), theory alone cannot determine whether individuals with high college entrance exam scores, which to a large extent measure ability, will study more or less than other individuals. On one hand, high ability students may receive higher non-pecuniary benefits and may retain more academic information from an additional hour of studying. On the other hand, given that high ability students may achieve the maximum grade at lower amounts of studying, an additional hour of studying may lead to higher grade and future benefits for the low ability student and the low ability student may be forced to study more just to "stay afloat." Rather similar conclusions exist for other variables. For example, while there are intuitively appealing reasons to believe that a person's study effort in college may be related to his high school grade point average, the strength of this relationship (and probably even the direction of this relationship) is uncertain from a theoretical standpoint and depends on factors such as how the school weights various factors when deciding which students to admit.[12]

Fortunately, unique time-use data collected as part of the BPS provide us with a unique opportunity to obtain direct evidence about the relationship between student characteristics, such as college entrance exam scores and high school grade performance, and college study effort. For reasons related to the specifics of the

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[12]Given basic intuition and evidence of the importance of time-use in S&S (2003b, 2004), it seems likely that time use also plays an important role in the high school grade production function. Thus, at least conditional on ability, people with higher high school grade point averages are likely to have studied more in high school. To the extent that the decision about time-use during college is based on underlying individual preference and production function parameters that also influence the high school time-use decision, one would expect a person's study effort during high school to be related to his/her study effort during college.

survey instruments that were used, we focus on the first (2000) BPS cohort. For this cohort, 343 out of 426 (.81) eligible students completed the baseline BPS survey which was a necessary for continued participation in the survey.

During this cohort's freshman year, six surveys were aimed primarily at eliciting information about how students were using their time. These surveys were sent to students via campus mail with strict completion deadlines.[13] With respect to time spent studying, we asked each student to think carefully about how he/she had been spending his/her time and to report the amount of time he/she had spent studying and doing homework (outside of class time) in the immediately preceding twenty-four hour period. The timing of the delivery and deadlines of the surveys implies that all time-use surveys were completed on a weekday. Thus, the answers to the time-use questions represent hours of study in a twenty-four hour weekday period.

The first six rows of Table 2 show descriptive statistics associated with the study questions for each of the six time-use surveys. On average, students study approximately 3.5 hours per day. The seventh row of Table 2 shows descriptive statistics when each person's reported hours are averaged over all of the time-use surveys that the person completed.[14] The sample distribution related to the reports from the first time-use survey (row 1) are shown in the remainder of Table 2.

The standard deviations of the entries in the first six rows indicate that there is a large amount of variation in study hours across individuals within a 24-hour period. The standard deviations of the entries in the seventh row indicate that permanent differences exist across people in study habits. However, the fact that the standard deviations in row 7 are smaller than those in rows 1- 6 suggests that the stochastic process that determines 24-hour study-times also contains a non-trivial non-permanent component. This motivates our estimation of a relationship between time-use and observable characteristics that contains both permanent and

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[13]The proportion of our first-wave respondents who answered each of these time-use surveys was .90, .82, .83, .77, .75, and .75. The slight decline in response rates between the second and sixth surveys is caused by the fact that approximately six percent of our respondents left school before the end of the first year.

[14]That is, we compute the average hours for each person across all of the time-use surveys that he/she completed. The descriptive statistics are the mean and standard deviation of these averages across all people in the sample.

transitory components. Specifically, we estimate three separate specifications

(1a) $Study_{i,t} = Constant_t + \gamma_{ACT} ACT_i + \mu_i + \varepsilon_{i,t}$

(1b) $Study_{i,t} = Constant_t + \gamma_{HSGPA} HSGPA_i + \mu_i + \varepsilon_{i,t}$

(1c) $Study_{i,t} = Constant_t + \gamma_{ACT} ACT_i + \gamma_{HSGPA} HSGPA_i + \mu_i + \varepsilon_{i,t}$.

$Study_{i,t}$ is the study-time for person i during one particular 24-hour period t when time-use was measured. The constant is allowed to vary across the time-use periods to take into account that some time-use surveys may have been collected at busier times during the year than other time-use surveys. μ_i is a person specific random effect that takes into account that some individuals have a "permanent" propensity to study more than others, and $\varepsilon_{i,t}$ represents transitory variation in study time.[15]

The estimates associated with specification (1a) are shown in the first column of Table 3. The point estimate (standard error) of γ_{ACT} is -.038 (.026) which implies that the hypothesis of no relationship between college entrance exam scores and study time cannot be rejected at traditional levels with high ACT students in the sample studying somewhat less than other students. The second column of Table 3 shows estimates of specification (1b) in which ACT is replaced by a person's high school grade point average, HSGPA. In this specification, the hypothesis of no relationship is rejected at all traditional significance levels with a point estimate (standard error) of .752 (.212). Further, this effect is quantitatively important. Using the descriptive statistics in Table 1, an increase in a student's HSGPA from one standard deviation below the mean to one standard deviation above the mean would increase average study-time in a day by approximately 25%. Finally, the third column of Table 3 shows estimates of specification (1c) which includes both ACT and HSGPA. In this specification, the estimated effect of HSGPA increases to 1.04 and a test of the null hypothesis of no relationship between HSGPA and study time is rejected with a t-statistic of 4.661.

Thus, the discussion and empirical results suggest that, if roommates do provide peer benefits at Berea, we may be more likely to find evidence of this in the relationship between college grades and a roommate's

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[15]We assume that the transitory component is serially uncorrelated across time. A formal test in S&S (2004) indicates that this is a reasonable assumption.

HSGPA than in the relationship between college grades and a roommate's ACT score.[16] In the next section

we examine whether this is the case, and we also examine the effect of an additional peer variable which our

discussion suggests might be related to whether a person is a good role model - although for institutional

reasons described later it does not make sense to try to verify this in this section using our time-use

information from the BPS.

V. Is there evidence of peer effects at Berea?

Section II, which indicates that students at Berea are of the type that might benefit from having good

peers, and Section III, which indicates that roommates are peers of potential influence, suggest that it is

reasonable to look for evidence of peer effects at Berea by taking advantage of exogenous variation in college

roommates. We do this in this section with our discussion and results in Section IV providing guidance for

our empirical work.

Section IV suggested that we should perhaps not expect to find evidence that a student's outcomes are

related to the ACT scores of his/her roommate but that we might find such evidence using the high school

GPA of his/her roommate. Here we suggest another variable that our intuition suggests might imply that a

student in our 1991-1996 sample is a good role model. Berea College is unique in that it offers a full tuition

and room and board subsidies to all entering students regardless of family income. S&S (2003a) finds that,

despite direct costs of approximately zero for all students, family income played an important role in the 1991-

1996 period in determining both the college grades and retention of students at Berea even after controlling

for observable characteristics including college entrance exam scores and high school grades. S&S (2003a)

discusses possible reasons that family income can play such an important role even when direct costs are zero.

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[16]It is possible that roommates with high test scores could serve as good peers through the role model
avenue even if they are not studying more than other students. These students do receive higher grades in college
and it is possible that they could transfer a view that good grade performance is important even if they are not
studying more. However, evidence about grade performance is not as easily observable to roommates as time-use.
In addition, it takes a substantial part of the semester before a significant amount of evidence about grade
performance becomes available to students.

Given additional evidence in S&S (2003c) that credit constraints are not particularly important for students at this school, some of the strongest possibilities are that students from low income families possess inferior study skills or lower propensities to study when they enter college, possess weaker beliefs about the importance of educational attainment, or do not receive the same amount of support and encouragement from their families if academic or social difficulties are encountered during college. If these type of explanations are relevant, then family income may play an important role in determining whether a person is a good role model. Unfortunately, it does not make sense to try to provide evidence about this matter using our time-use information from the 2000-2001 period because, while the drop-out rate of students (who can be thought of as a group of low income students) at Berea remained high during this period, the strong relationship between family income and grades (and retention) that was observed within the students at Berea during the 1991-1996 period is not observed during the 2000-2001 year. Nonetheless, given the theory/intuition discussed in Section IV and the findings of S&S (2003a, 2003c) it seems sensible to take advantage of variation in family income when looking for evidence of peer effects at Berea.

Institutional details imply that the roommate assignment process is random. Nonetheless, given the importance of the randomness in this application, it is worthwhile to provide as much indirect evidence as possible that the process is indeed random. Table 4A shows the deterministic portion of a regression of a student's ACT score on his/her roommate's ACT score (RACT) and a series of year dummy variables.[17] The t-statistics associated with a test of the null hypothesis that the effect of RACT is zero are .023 and 1.073 for females and males respectively. Table 4B shows the deterministic portion of a regression of a student's high school grade point average (HSGPA) on the his/her roommate's high school grade point average (RHSGPA) and a series of year dummy variables. The t-statistics associated with a test of the null hypothesis that the effect of RHSGPA is zero are .702 and 1.188 for females and males respectively. Table 4C shows the deterministic portion of a regression of a student's family (INCOME) on the income of his/her roommate

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[17]Year dummies are needed to allow for the possibility that average test scores may vary somewhat by year.

(RINCOME) and a series of year dummy variables. The t-statistics associated with a test of the null hypothesis that the effect of RINCOME is zero are .667 and 1.162 for females and males respectively. Thus, this indirect empirical evidence supports our belief, based on our knowledge of institutional details at Berea, that the roommate assignment process was random during this period.

The random assignment of roommates allows our methods for examining the influence of peer effects to be straightforward. For the purpose of examining grade outcomes, we begin by examining the results from the following three separate OLS regressions related to the first semester grade performance G_i.

(2a) $G_i = \text{Constant} + \alpha_{ACT}ACT_i + \alpha_{RACT}RACT_i + v_i$

(2b) $G_i = \text{Constant} + \alpha_{HSGPA}HSGPA_i + \alpha_{RHSGPA}RHSGPA_i + v_i$

(2c) $G_i = \text{Constant} + \alpha_{INCOME}INCOME_i + \alpha_{RINCOME}RINCOME_i + v_i$.

The random assignment of roommates implies that $RACT_i$, $RHSGPA_i$, and $RINCOME_i$ are uncorrelated with v_i which captures unobservable determinants of grade performance such as motivation, study skills, and study effort.

We make the specifications in (2a)-(2c) as simple as possible in the interest of making results easy to interpret. In particular, our initial approach of including one peer variable at a time allows the specifications to provide direct evidence about whether there actually exist people who are good peers at Berea without having to take into account relationships between multiple, strongly related peer variables. It is also worth noting that the random assignment of students implies that it would not be problematic to examine specifications that include roommate characteristics but do not include a student's own characteristics. However, we choose to include the student's own characteristics because knowing the estimated effect of the these variables is useful for understanding the importance of the estimated peer effects.

In all cases we estimate models separately by sex. The first three columns of Table 5a show the results of specifications (2a)-(2c) for females. The first column of Table 5a reveals no evidence of a relationship between college grades and roommate ACT score; the estimated effect of RACT is .0015 and a test of the null hypothesis that the effect of RACT is zero yields a t-statistic of approximately .33. This finding is consistent

with the discussion and empirical evidence in Section IV which suggested reasons why such a relationship might be unlikely to exist. Instead, Section IV suggested that, if peer effects are important in this context, it would be more likely to see evidence in the relationship between college grades and roommate high school grade point average. The second column of Table 5a provides such evidence; the estimated effect of RHSGPA for females is .134 and a test of the null hypothesis that the effect of RHSGPA is zero yields a t-statistic of 1.88. The third column of Table 5a reveals additional evidence of peer effects for females. The estimated grade effect of a \$10,000 increase in roommate family income is .047 and the t-statistic associated with a test that RINCOME has no effect is 1.96.

The results of Section IV indicated that a person's HSGPA has a larger effect on study-effort after conditioning on the person's ACT score. This suggests that RHSGPA may better differentiate between a roommate's value as a role model in a specification that also included RACT. This motivates the specifications in the fourth and fifth columns of Table 5a where RACT and ACT have been added to specifications (2b) and (2c) respectively. In these specifications the point estimates associated with RHSGPA and RINCOME increase to .180 and .054 respectively, and tests of the null hypotheses that RHSGPA and RINCOME are unrelated to college grades yield t-statistics of 2.33 and 2.44 respectively in the two specifications.

The five columns of Table 5b show the results for males. Consistent with the discussion/evidence from Section IV and the finding for females, the first column of Table 5b reveals no evidence of a relationship between college grades and roommate ACT score for males. However, Columns 2-5, which reveal no evidence of a relationship between a student's grades and the high school grade point average of his roommate and no evidence of a relationship between a student's grades and the family income of his roommate indicate differences in the importance of peer effects by sex. We also find evidence of such differences when we estimate specifications for retention that are analogous to the specifications in Tables 5a and 5b.[18]

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[18]For females we find strong evidence of a relationship between a roommate's family income and retention. Specifically, using a probit specification analogous to specification (2c) we find that the probability that a student returns for her second year increases by approximately .036 when her roommate's family income increases

There is other recent evidence in the literature that peer effects may differ by gender. For example, Hoxby (2000) finds evidence that students have better math performance when they are in classrooms that contain more females. Differences in the importance of peer effects by sex could arise for many reasons. In the educational context of this paper, one possibility is that females may be more accepting of roommates who are from different backgrounds, and, as a result, may spend more time with their assigned roommates than males. The BPS allows us to provide some empirical evidence that this may be the case. Specifically, when we repeat the analysis in Section III after separating the sample by sex, we find differences between males and females. For example, we find that .438 of females but only .297 of males report that their randomly assigned roommates are one of their four best friends. A test that the population proportions are the same for males and females is rejected at all traditional significance levels with the test yielding a t-statistic of 2.78. We found that, on average, female students in the sample spent about 20% more time with their roommates. However, given small relatively sample sizes, it was not possible to reject the null hypothesis that the population mean time spent with roommates is the same for males and females.

An important policy question is whether certain types of students can receive substantial peer benefits without other students incurring substantial costs. The discussion in this paper suggests that this could be the case. For example, it seems likely that a student with good study skills and/or strong beliefs about the importance of educational attainment would not suffer much from an arrangement in which she imparts these skills and beliefs on a roommate who came to school with poor study skill and/or weaker beliefs about the importance of educational attainment.

To get a sense of whether the net gains of combining students from diverse backgrounds might be positive we focus on women and modify the specification in the last column of Table 5a which was found to provide the strongest evidence of peer effects in Table 5. Specifically, in Table 6 we replace the $INCOME_i$

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by \$10,000. A test that roommate family income plays no role in retention is rejected at traditional significance levels with a t-statistic of 2.63. However, consistent with our results from Table 5b, for males we found no evidence of a relationship between college retention and any of the peer variables.

and RINCOME$_i$ variables in the last column of Table 5a with an indicator of whether student i is from a high income background and is paired with roommate from a high income background (HH$_i$), an indicator of whether student i is from a high income background and is paired with a roommate from a low income background (HL$_i$), and an indicator of whether student i is from a low income background and is paired with a roommate from a high income background (LH$_i$). The estimated effects are relative to an omitted category in which student i is from a low income family and is paired with a roommate from a low income family. Not surprisingly, the results indicate that a high income student who is assigned a high income roommate (HH$_i$) performs better than a low income student who is assigned a low income roommate. What is of more interest are the estimates associated with the LH and HL pairs. The statistically significant coefficient (pvalue=.058) associated with the former implies that a low income student who is paired with a high income roommate performs significantly better than a low income student who is paired with another low income student. Similarly, the statistically significant coefficient (pvalue=.077) associated with the latter implies that a high income student who is paired with a low income roommate performs significantly better than a low income student who is paired with another low income student and statistical tests do not reject the null hypothesis that the effect of HH and HL are equal. Thus, the results suggest that low income students may be helped in a non-trivial fashion by being paired with higher income peers without the higher income peers incurring substantial costs. This finding of a net gain to diversification was even more clearly apparent when we modified the specification in Column 4 of Table 5a in a similar fashion by constructing the HH, HL, LH, and LL indicators on the basis of the high school grades of a student and her roommate.[19]

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[19]In this case, the estimated effect (standard error) of HH (HSGPA high, RHSGPA high), HL (HSGPA high, RHSGPA low), and LH (HSGPA low, RHSGPA high) were .654 (.099)*, .610 (.098)*, and .186 (.098)* respectively. The latter reflects the grade benefit for the low HSGPA person of being assigned a roommate with high RHSGPA relative to being assigned a roommate with low RHSGPA. The difference between the first two estimates is an estimate of the harm that is incurred by a high HSGPA person who is assigned a roommate with a low RHSGPA.

V. Conclusion

First year grade outcomes and drop-out decisions depend, in part, on the amount of effort a student puts into studying, the quality of his/her study time, and his/her beliefs about the importance of educational attainment. These factors may be influenced in the short run by the actions and beliefs of peers. This paper finds evidence which suggests that this avenue is important at Berea College and provides some direct evidence about why the importance of peers may vary by sex.

The findings and discussion in this paper are very consistent with the recent work of Kremer and Levy (2003). They find that a student's grade performance during college is strongly related to his/her roommate's pre-college drinking behavior and conclude that "Overall, these findings are more consistent with models in which peers change preferences than models in which they change endowments."

There are a couple of other things to note. First, the finding that a particular variable at Berea is related to whether a person is a good peer does not imply that a similar finding should be expected between the same variable and grade performance at a different school. There are several reasons the same relationship might not exist. Among these: 1) different types of students may be affected to a much different degree by peers than students at Berea and 2) the relationship between a particular observable characteristic, such as a person's high school grade point average or family income, and whether the person is a good role model (e.g., as suggested in this paper by the relationship between the characteristic and the person's time-use) may be quite different at a different school because these relationships will depend on a complex set of factors including the admissions process at a particular school. Nonetheless, given the difficulty of credibly identifying peer effects in education, much of the literature on peer effects in education has had the goal of trying to find compelling evidence that peer effects can matter. This paper provides evidence that peer effects can play a non-trivial role in higher education.

Second, the discussion in the paper suggests reasons that peer academic ability per se should probably not be expected to play an important role in the short-run academic outcomes studied in the college roommate literature, and the empirical work provides evidence in support of this notion. Thus, to the extent that the

measures used in Sacerdote (2001) and Zimmerman (2003) primarily measure ability per se, this paper provides a possible explanation for the lack of evidence found in these previous papers. However, it is important to stress that the notion that peer ability per se does not matter in this particular educational context should not be taken as evidence that it does not matter more generally. For example, suppose that an elementary student is placed in a classroom with students who have the same study habits and beliefs about the importance of schooling but higher academic ability. Even in the short-run the student may benefit from these peers because the academic interactions between students in this context (e.g., students who spend the entire day in the same elementary school class) may be much greater than the academic interactions of college roommates. Further, even if the student's ability is to a large extent fixed in the short run, having high ability peers may make a difference over the many years that the students spends with his elementary classmates.

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Table 1 descriptive statistics -administrative sample used in Section V

	female n=676 mean standard deviation	male n=619 mean standard deviation
Observable Characteristics		
black	0.1	0.1
home is within 2 hours of Berea	0.44	0.44
ACT own ACT	43.27 6.60	41.67 7.06
INCOME own income/10000	2.02 1.28	2.27 1.37
RACT roommate ACT	43.24 6.64	41.61 6.98
RINCOME roommate family income/10000	2.02 1.29	2.27 1.37
HSGPA own high school GPA	3.35 .45 (n=474)	3.07 .51 (n=464)
RHSGPA roommate high school GPA	3.34 .45 (n=474)	3.07 .51 (n=464)
Student Outcomes		
first semester grades - G	2.62 .79 (n=638)	2.31 .94 (n=585)
retention -returned for second year - R	0.72	0.64

Table 2: descriptive statistics -study time from time-use surveys

REPORTED STUDY TIME	
	mean (standard deviation)
	study hours in previous day
survey 1	3.41 (2.11)
survey 2	3.50 (2.16)
survey 3	3.52 (2.18)
survey 4	3.48 (2.16)
survey 5	3.39 (2.22)
survey 6	3.48 (2.20)
average study across surveys	3.42 (1.62)
SAMPLE DISTRIBUTIONS Hour Category	survey 1 study hours in previous day
[0,1) Hour	0.055
[1,2) Hour	0.095
[2,3) Hour	0.227
[3,4) Hour	0.208
[4,5) Hour	0.186
[5,6) Hour	0.098
[6,7) Hour	0.073
[7+) Hour	0.054

Table 3 The relationship between observable characteristics and study-time. BPS data

parameter	Specification (1a) ACT estimate (std. error)	Specification (1b) HSGPA estimate (std. error)	Specification (1c) ACT & HSGPA estimate (std. error)
constant (time-use survey 1)	4.346 (.646)*	.826 (.769)	2.096 (.835)*
constant (time-use survey 2)	4.405 (.638)*	.886 (.763)	2.157 (.826)*
constant (time-use survey 3)	4.377 (.640)*	.855 (.764)	2.123 (.829)*
constant (time-use survey 4)	4.359 (.641)*	.847 (.764)	2.118 (.828)*
constant (time-use survey 5)	4.331 (.647)*	.814 (.755)	2.084 (.835)*
constant (time-use survey 6)	4.451 (.644)*	.933 (.776)	2.197 (.837)*
standard deviation μ_i	1.349 (.064)*	1.317 (.067)*	1.278 (.068)*
standard deviation $\varepsilon_{i,t}$	1.730 (.027)*	1.728 (.027)*	1.727 (.027)*
γ_{ACT} - ACT	-.038 (.026)		-.095 (.028)*
γ_{HSGPA} -HSGPA		.758 (.212)*	1.041 (.223)*

* represents statistical significance at a .10 level.
Table 3 shows estimates of specfications (1a)-(1c). The specifications are estimated using multiple time-use observations for 291 individuals from the BPS.

Table 4a - Evidence of randomness. OLS regressions of ACT on RACT and time dummy variables.
note: g1(year) and g2(year) are linear functions of year dummies (time dummy coefficients not shown).
Standard errors in parentheses below the points estimates.

Females n=676
$E(ACT_i)=42.42 + .0009\ RACT_i + g1(year)$
        (1.74) (.038)

Males n=622
$E(ACT_i)=39.51 + .044\ RACT_i + g2(year)$
        (1.82) (.041)

Table 4b - Evidence of randomness. OLS regressions of INCOME on RINCOME and time dummy variables.
note: g3(year) and g4(year) are linear functions of year dummies (time dummy coefficients not shown).
Standard errors in parentheses below the point estimates.

Females n=445
$E(HSGPA_i)=3.244 + .033\ RHSGPA_i + g3(year)$
          (.148) (.047)

Males n=438
$E(HSGPA_i)=2.91 +\ \ .057\ RHSGPA_i + g4(year)$
          (1.82) (.048)

Table 4c - Evidence of randomness. OLS regressions of INCOME on RINCOME and time dummy variables.
note: g5(year) and g6(year) are linear functions of year dummies (time dummy coefficients not shown).
Standard errors in parentheses below the point estimates.

Females n=676
$E(INCOME_i)=2.10 + .026\ RINCOME_i + g3(year)$
          (.148) (.039)

Males n=622
$E(INCOME_i)=2.451 + .050\ RINCOME_i + g4(year)$
          (1.82)   (.043)

Table 5a first semester grades and peer effects for females for three different peer measures

	Spec. (2a) peer - ACT n=638 estimate (SE)	Spec. (2b) peer - RHSGPA n=445 estimate (SE)	Spec (2c) peer - RINCOME n=638 estimate (SE)	peer - RHSGPA & RACT n=445 estimate (SE)	peer - RINCOME & RACT n=638 estimate (SE)
OWN VARIABLES					
constant	.589 (.264)*	-1.322 (.359)*	2.359(.073)*	-1.121 (.382)*	.443 (.264)*
ACT	.045 (.004)*			.027 (.005)*	.044 (.0043)*
HSGPA		.693 (.077)*		.689 (.077)*	
INCOME			.085 (.024)*		.056 (.022)*
PEER VARIABLES					
RACT	.0015 (.0044)			-.008 (.005)	.0008 (.004)
RHSGPA		.134 (.071)*		.180 (.077)*	
RINCOME			.047 (.024)*		.054 (.022)*
	R^2=.148	R^2=.276	R^2=.027	R^2=.280	R^2=.165

* represents statistical significance at a .10 level.

Table 5b first semester grades and peer effects for males for three different peer measures

	Spec. (2a) peer - RACT n=585 estimate (SE)	Spec. (2b) peer - RHSGPA n=438 estimate (SE)	Spec. (2c) peer - RINCOME n=585 estimate (SE)	peer - RHSGPA & RACT n=438 estimate (SE)	peer - RINCOME & RACT n=585 estimate (SE)
OWN VARIABLES					
constant	.480 (.299)*	-.701 (.302)*	2.329(.096)*	-1.116 (.356)*	.528 (.305)*
ACT	.043 (.005)*			.018 (.006)*	.043 (.005)*
HSGPA		.913 (.074)*		.812 (.081)*	
INCOME			.036 (.028)		.014 (.027)
PEER VARIABLES					
RACT	.0009 (.0052)			.002 (.006)	.0016 (.005)
RHSGPA		.067 (.075)		.047 (.081)	
RINCOME			-.042 (.028)		-.039 (.027)
	R^2=.106	R^2=.276	R^2=.006	R^2=.282	R^2=.109

* represents statistical significance at a .10 level.

Table 6 first semester grades and peer effects for females with income categories n=638

	females mean (standard deviation)
constant	.506 (.267)
ACT	.045 (.004)*
RACT	.0012 (.0044)
HH - student high income, roommate high income	.195 (.082)*
LH - student low income, roommate high income	.153 (.080)*
HL - student high income, roommate low income	.142 (.079)*
	R^2=.157

* represents statistical significance at a .10 level for OLS regression of first semester grades.

Appendix

Question O. Please write down the **first and last names** of the four people (male or female) that have been your best friends at Berea College during **this spring term (2002) .** That is, write down the names of the four people with whom you have been spending the most time during the spring term. Also please mention how many hours per week you spend with each person and how many hours you spend studying or talking about classes with each person.

Please include your boyfriend/girlfriend or husband/wife.

Also include your roommate if he/she is among your four best friends.

Place a check next to the name of your boyfriend/girlfriend or husband/wife.

Four best friends	Hours spent with this person in a typical week (don't include sleep hours)	Hours spent with this person studying /talking about classes in a typical week
1. _____	_____	_____
2. _____	_____	_____
3. _____	_____	_____
4. _____	_____	_____

Place a check next to the name of your boyfriend/girlfriend or husband/wife.

Please fill out the following information for your current roommate and boyfriend/girlfriend spouse. Note that your current roommate and boyfriend/girlfriend/spouse (if any) should also appear above if they are among your four best friends.

	Hours spent with this Person in a typical week (don't include sleep hours)	Hours spent with this person studying/talking About classes in a typical week.
Current Roommate's Name_____	_____	_____
Boyfriend/Girlfriend/Spouse Name _____	_____	_____