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Peer Effects and Alcohol Use Among College Students

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ABSTRACT

This paper examines a natural experiment in which students at a large state university were randomly assigned roommates through a lottery system. We find that on average, males assigned to roommates who reported drinking in the year prior to entering college had one quarter-point lower GPA than those assigned to non-drinking roommates. The 10th percentile of their college GPA is half a point lower than among males assigned non-drinking roommates. For males who themselves drank frequently prior to college, assignment to a roommate who drank frequently prior to college reduces GPA by two-thirds of a point. Since students who drink frequently are particularly influenced by frequent-drinking roommates, substance-free housing programs could potentially lower average GPA by segregating drinkers. The effect of initial assignment to a drinking roommate persists and possibly even grows over time. In contrast, students' college GPA is not influenced by roommates' high school grades, admission test scores, or family background. Females' GPAs are not affected by roommates' drinking prior to college. Overall, these findings are more consistent with models in which peers change preferences than models in which they change endowments.

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1. Introduction

Although economics has historically taken preferences as given, focusing on the effects of changing endowments, technology, or institutions, a recent theoretical literature examines endogenous preference formation, in particular through peer influences and through habit formation. For example, Becker and Murphy [1994] argue that current consumption of addictive goods is complementary with future consumption, and Laibson [2001] presents a cue theory of consumption, in which exposure to cues triggers addictive cravings. Akerlof [1997] and Akerlof and Kranton [2000] model choice of identity.

Universities seem an apt place to look for endogenous preference formation both from peer influences and through habit formation. Students are separated from parents and many of their previous peers, and have an opportunity to choose a new identity. College is also a main locus of substance abuse, with 40% of students reporting binge drinking at least once within the past two weeks (Wechsler et al., 2000).[3] After tobacco, alcohol is the most frequently abused drug in the United States and many addictions develop in college.

Universities also offer an opportunity to overcome some of the notorious econometric problems associated with identifying peer effects. This paper examines a natural experiment in which students at a large state university are randomly assigned roommates through a lottery system.

We find that on average, males assigned to roommates who reported drinking in the year prior to entering college had one quarter-point lower GPA than those assigned to

[3] In their 1999 survey, Wechsler et al. defined binge drinking as "the consumption of at least five drinks in a row for men or four drinks in a row for women during the 2 weeks before the completion of the questionnaire."

non-drinking roommates. Peer effects are concentrated at the bottom of the GPA distribution: assignment of a roommate who drank in high school reduces the 10^{th} percentile of GPA by 0.43 points. Peer effects persist and perhaps even grow stronger over time; assignment of a first-year roommate who drank prior to college reduces second-year GPAs by almost a half point. Students who themselves drank frequently in high school are most affected by frequent-drinking roommates; their average GPA decreases by almost a full point on average if their roommate drank frequently prior to college. These effects are strong relative to the effect of own academic background.

Just as important as the peer effects we find are those we do not find. In contrast to the strong effect of roommate drinking on males' academic performance, we find no evidence that females' GPAs are affected by roommates' drinking prior to college. We also find no evidence that roommates' prior academic performance or socio-economic background affects student GPA.

Our findings are more consistent with models in which peer effects operate by influencing preferences than with those in which peers change narrowly interpreted endowments, for example by providing help with homework or by disrupting study. A simple model in which peer effects work by disruption of study is hard to reconcile with the persistence of peer effects into the second year of university despite the fact that the vast majority of students change roommates from their first to second year of college. This, together with the absence of peer effects from roommate prior academic performance or socio-economic background, suggests that peer effects in this environment work much more strongly through preferences than through narrowly-interpreted endowments.

Given that students who themselves drank frequently prior to college are most affected by frequent-drinking roommates, policies that tend to concentrate such students together will reduce average GPA. This may be a side effect of many universities' policies of allowing students to choose "substance-free" housing.

This paper is organized as follows. Section 2 reviews the literature. Section 3 describes the institutional background and the data we use, and checks whether roommates are randomly assigned. Section 4 examines the effect of randomly assigned roommates' pre-college characteristics on college GPA. Section 5 examines how naïve estimates of peer effects differ in a self-selected sample, arguing that in our context, selection may actually lead to a downward bias on naïve estimates of peer effects. Section 6 presents simple models in which roommate drinking affects GPA either by disrupting study or through peer effects on preferences and habit formation. Section 7 argues that the effect of roommate drinking persists over time and is strongest at the bottom of the GPA distribution and for people who themselves drank in high school, consistent with the model of peer effects on preferences and habit formation. Section 8 analyzes the effects of different sorting patterns on average GPA. Section 9 concludes.

2. Literature

Many studies argue that substance abuse is subject to substantial peer effects by documenting a positive association between teenagers' substance use and substance use among their peers, controlling for other factors (e.g., Botvin et al. 1998, Cumsille et al. 2000, Leibsohn 1994, Brook et al. 1990, Reis and Reily 2000, and Wechsler et al. 1995).

However, it is often difficult to empirically determine whether a correlation between peers' outcomes is due to peer effects, to self-selection of similar peers, or to common shocks affecting the peer group. Sacerdote (2001) makes an important advance over the previous literature by exploiting random housing assignment to assess peer effects among Dartmouth students.[4] While Sacerdote finds strong evidence that randomly-assigned roommates have correlated first-year GPAs, he finds only weak evidence that students are affected by pre-determined roommate characteristics.[5] The distinction is important because an alternative interpretation of high correlation of outcomes but weak and non-robust effects of pre-determined roommate variables on GPA is that roommates experience common shocks. Sacerdote discounts this possibility, arguing that his results are robust to controlling for the residence hall to which students are assigned. However, common shocks could also occur at the room or floor level within

[4] Zimmerman (1999) examines the effect of roommate assignments at Williams College, but several data limitations make it difficult to draw any firm conclusions from this work: 1) Students who were assigned requested roommates were not excluded from the analysis; 2) the details of the roommate assignment process are not known with certainty for much of the sample period; and 3) roommate assignment was only random conditional on housing preferences, but the analysis does not control for housing preferences since data on these preferences have been destroyed, so correlations between roommate outcomes could be due to similarities between students who listed similar housing preferences.

[5] Sacerdote notes that "the effects on GPA from randomly assigned roommate background are modest in size and statistical significance." In particular, he assesses the effect of an academic background index incorporating SAT scores and high-school performance on roommate outcomes. When entered linearly, the roommate academic background index is not a significant predictor of GPA. If the roommate index is split into dummy variables for the top 25%, bottom 25% and middle 50% of scores, it enters significantly, but when one controls for own academic background, as seems appropriate, it is significant only at the 10%

residence halls. For example, roommates may be more likely to both get the flu or mononucleosis at the same time. They may choose the same teaching assistant in classes they take together, and if teaching assistants vary in ability or grading standards this will produce correlation in roommates' GPAs. Roommates will be subject to common shocks to the extent that rooms may differ in size, quality, or soundproofing. Roommates will have the same resident advisor on their floor, and variation in the extent to which resident advisors support students with emotional problems, enforce alcohol policies, or encourage students to take difficult classes could produce correlation in roommate outcomes. Correlation between outcomes is thus insufficient to determine the extent to which the underlying probabilities of various outcomes for a particular student depend on the characteristics of the peers with whom she interacts. To see this, consider a hypothetical set of students who each are indifferent between seeing a movie or studying on a particular night, and hence flip a coin to decide. Suppose that roommates coordinate their decisions based on a single coin flip, while non-roommates each flip their own coin. In this example, roommate outcomes will be correlated, but a student's probability of studying does not depend on his or her roommate assignment. Yet unless pre-determined peer characteristics affect outcomes, parents, students, and policymakers should be indifferent to choice of peers. We therefore focus on the effect of roommates' pre-determined characteristics on student outcomes.

The Dartmouth study finds that first-year roommates' GPAs are correlated, but their senior year GPAs are not correlated. This is consistent with the possibility that correlation in first-year GPA is due in part to common shocks, such as flu or a bad

level. The effect of roommate academic background thus does not seem particularly robust in the Dartmouth sample.

teaching assistant, with minimal long-run impact. In contrast, we find that the effect of roommates' high-school drinking on GPA persists over time, consistent with a habit formation model.

A further advantage of focusing on the effect of roommates' predetermined characteristics on student outcomes is that this approach sheds light on the channels underlying peer effects. Our finding that roommate academic and socio-economic background does not affect GPA but that roommate drinking prior to college strongly reduces males' college GPA suggests that peer effects in this context operate through preferences rather than endowments, and points to a potential role for habit formation.

A further difference between the studies is that in addition to the sample of students who participated in the lottery process, we also have access to a sample of students who selected their own roommates, which allows us to analyze the importance of the selection problem in this context. Finally, our analysis differs from Sacerdote's in that we examine a large state university, which may have quite different social dynamics than Dartmouth.

3. Institutional Background and Data

This section reviews the institutional background of the university (sub-section 2.1) and the roommate assignment process (sub-section 2.2). It then confirms that the data we use are consistent with random assignment of roommates (sub-section 2.3).

3.1. Institutional Background

Our data are taken from a large, academically strong, state university. Students at the university performed well in high school, achieving an average aptitude test score around the 90th percentile of the national distribution and an average grade point average between 3.5 and 4.0. The university is only slightly above average in student consumption of beer, wine and liquor[6] and was never listed as one of the top twenty party schools from 1997-2002 in the Princeton Review's annual best 311 college rankings.

Students at this university typically live in residence halls their first year at the university, but then move off campus, either to apartments shared with other students or to fraternities. A survey administered in the winter of 2002 to a sample of students who entered the university in 1998-2000 and who were randomly assigned to their first-year roommate found that 67% moved out of the dormitories by sophomore year, with 20% joining fraternities. Fraternities are associated with heavy drinking: 73% of students in the survey who joined a fraternity report drinking more than once a week over the past year compared to 37% of students who never joined a fraternity, and 45% of students who joined a fraternity report binge drinking more than once a week over the past year compared to 25% of non-fraternity students.[7] A rush process which involves a sequence of fraternity parties takes place during students' first year, but students do not usually move into the fraternity until their second year. As discussed above, drinking is a major problem in many U.S. universities. Since the increase in the legal drinking age to 21 made drinking illegal for the overwhelming majority of first-year college students,

[6] Data for the university was compared to aggregate national data ["CIRP/UMR National Results." Updated 20 June 2001. <http://web.umr.edu/~assess/results/cirpdrht.html>. Cited June 22, 2002.].

[7] Binge drinking was defined according to Wechsler et al. (1999): the consumption of at least five drinks in a row for men or four drinks in a row for women. These percentages reflect drinking after joining the fraternity.

universities have had to crack down on public drinking. One side effect has been to move drinking inside students' rooms, potentially increasing the extent to which students are affected by their roommates' drinking habits.

3.2. The Roommate Assignment Process

A subset of first-year students at the university are assigned roommates randomly, conditional on gender and a few housing preferences. Since our identification strategy takes advantage of the roommate assignment process, it is worth reviewing this process. First-year students can elect to live in an enrichment living center, in which case they need to submit an essay to be considered for admission, or to select a specific roommate, in which case the housing office will honor the request as long as it is mutual. Those who opt for neither option and who meet the lottery deadline are assigned rooms randomly, conditional on gender and four basic housing preferences: environment (substance-free housing, non-smoking roommate, do not mind smoking roommate, and smoker), room type (single, double, triple occupancy, and other), geographic area of campus, and gender composition of hall and corridor. For some of these preferences, students could indicate a first, second, and third choice.

For students participating in the lottery, roommate assignment should be random, conditional on gender and basic housing preferences. We call a combination of gender and housing preferences (including first, second, and third choices when applicable) a *cell.* In all regressions below, we control for the cell that a student has chosen.

Our main sample (henceforth called the "lottery sample") consists of those students who did not request a particular roommate, elected not to live in an enrichment living center, met the lottery deadline, and were assigned to live with at least one

roommate. Of the approximately 7,500 first year students from the 1997 and 1998 entering classes for whom we had data, 25% decided to live in enrichment living centers, 18% requested particular roommates, 30% lived alone as first year students, and 57% of the students did not meet the lottery deadline, leaving 1,357 students in our sample. A second group of students who requested their roommate will be used for comparison purposes and is termed the "roommate request sample."

Randomization within the lottery sample implies that our results will be internally valid for this population but, to assess external validity, it is useful to compare lottery participants to the population as a whole. Table 1 compares the lottery sample with the whole sample of entering students and with the roommate request sample. Students who were randomly assigned are fairly similar to those who were not, but the lottery sample contains a slightly larger proportion of females than the other two samples and a much smaller percentage of African-American students (3% in the lottery sample vs. 7% in the whole sample and 10% in the roommate request sample). Lottery students perform slightly better academically (as measured by cumulative GPA in both college and high school), although they do not score higher on the admissions test.

Of course, the fact that students made it into our sample suggests that they are different in some ways from other students. The students in our sample are likely to have few pre-existing social ties at the university, since they did not select a roommate. This lack of pre-existing social ties may make them particularly susceptible to peer influences. Moreover, at least some of those with a strong identity would have opted for an enrichment learning center, and thus left our sample.

Our baseline data is based on administrative records and the Entering Student Survey of the Cooperative Institutional Research Program (also known as the CIRP), which was taken by 89% of students who entered the university in 1997-1998. Students fill out the CIRP at the beginning of orientation, which is offered to incoming students in weekly sessions throughout the summer. According to housing officers, very few students will have met their roommate before filling in the survey.

The Entering Student Survey contains a section in which respondents are asked whether they undertook certain activities frequently, occasionally, or not at all during the last year.[8] The list of activities includes "Drank beer" and "Drank wine or liquor."[9] We classified as "frequent drinkers" the 15% of the population who answered "frequently" to at least one of the two drinking-related questions. We classified as "occasional drinkers" the 53% of the population who were not "frequent drinkers," but answered "occasionally" to at least one of the two drinking-related questions. Students who reported not drinking beer, wine, or liquor in the last year were classified as "non-drinkers." There are only small differences in self-reported high-school drinking behavior between males and females; however, male and female students may have different interpretations of "frequent" and "occasional" drinking.

We use the term "roommate" to refer to the initial roommate who was assigned to occupy the same room on the first day of the academic term. Our estimates thus have an Intention to Treat (ITT) interpretation. Since the university does not allow roommate changes during the first six weeks of classes (except for extreme cases involving

[8] 99% of our sample students came straight from high school to college, so for most students the term "last year" refers to their senior year in high school.

violence), and strongly discourages any roommate changes during the first year, less than 5% of students switch roommates during their first year. Hence using initial roommate characteristics as instrumental variables for actual roommate characteristics would be likely to increase slightly our estimates of peer effects.

About 81% of students in our sample had only one roommate. For those students with multiple roommates, roommate characteristics were defined as the average value of each roommate's characteristics if the characteristic was a continuous variable. Students who had at least one roommate who drank frequently were coded as having a frequent-drinking roommate. Students who had at least one roommate who drank occasionally but no frequent-drinking roommate were coded as having an occasional-drinking roommate. Sample sizes were too small to examine whether students are influenced by the average of their roommates' characteristics or by other measures (such as the minimum or maximum) of roommate characteristics.

2.3. Random Assignment Checks

Information from the university suggests that students from the lottery sample with the same housing preferences and gender should be randomly assigned to their roommates and residence halls. To verify this, we first interviewed housing officers and reviewed the documentation of the computer software used to make housing assignments. We then verified that initial roommates' background characteristics were not significantly correlated by running regressions in which student background characteristics (such as admissions test score, high school GPA, parental background, high school activities,

[9] Response rates for these questions are above 98% of those who filled in the CIRP.

goals, views, etc.) were regressed on their initial roommates' average and a set of housing preference cell dummies.[10]

Given that the error terms in the regressions described above may not be normally distributed, we assessed significance by comparing the coefficient from running the regression on the actual data to the distribution of coefficients obtained from regressions ran on 1,000 simulated samples. In each simulated sample, we matched each reference student with a randomly chosen roommate from the pool of roommates originally matched to reference students in the cell. We checked for correlation in 151 variables. Ten out of 151 regression coefficients turned out significant for the lottery sample, out of which seven had a positive sign and three had a negative sign. The distributions of the coefficients and the t-statistics obtained from the simulations are approximately normal. Our test which compares the regression results using the actual data to the simulated distributions shows that 141 variables fall within the 2.5 and 97.5 percentiles and 10 variables are out in the 5% tail of the distribution.[11] If roommates were indeed assigned randomly and the 151 characteristics were independent, then a calculation using the binomial theorem shows that we should expect 10 or more variables to be in the 5% tail with probability 22.5%. For plausible degrees of correlation, the probability would be even greater.

The test we employed has reasonable power. In the "roommate request" sample, 52 of 151 coefficients are in the 5% tail. In a set of artificial data where the top 10% of

[10] In performing these random assignment checks, we restricted the sample to contain each roommate pair only once. Allowing students to appear both as a reference student and then as a roommate would induce an artificial negative coefficient. To see this, note that in a cell with two observations, the match AB where A is the reference student and the match BA where B is the reference student, a regression of own characteristics on roommate characteristics within the cell will yield a negative coefficient because if a student has a higher level of the characteristic than the cell average then his roommate has a lower than the cell average. Since many cells are small, this bias is significant.

[11] We find similar results using a standard t-test.

students in each cell in the reference sample and the roommate sample were matched together and the remaining 90% were randomly matched, 18 out of 151 coefficients are in the 5% tail of the simulated distribution. If characteristics were independent, this would occur with probability 0.0006.

4. Effect of Roommates' Pre-College Characteristics on College GPA

The main outcome we examine in this paper is cumulative GPA at the end of the summer of 1999, which corresponds to GPA at the end of the second year for the 1997 cohort, and to GPA at the end of the first year for the 1998 cohort. Controlling for cell dummies ensures that we examine differences in outcomes among students who expressed identical housing preferences, but were assigned roommates with different backgrounds.

In the lottery sample as a whole, neither roommates' academic background variables (high school GPA and admissions test score[12]) nor roommates family background (parental income and education) are associated with a student's college GPA (Table 2).

When males and females are grouped together, the point estimate of the effect of roommates' high school drinking on GPA is negative but insignificant (Table 2, columns 4 and 5). However, this average treatment effect conceals dramatic heterogeneity.

[12] Since some students took only the SAT, others took only the ACT, and some took both, we standardized test scores based on concordance tables [Pommerich et al., 2000] and restandardized this measure by subtracting the sample mean and dividing by the standard deviation of the sample. Hence the regression coefficients on this variable can be readily interpreted as the change in the dependent variable associated with an increase of a standard deviation in admissions test scores. For our sample, a standard deviation in admissions test scores is approximately equivalent to 110 points in the SAT exam and to 2.7 points in the ACT exam.

Males' GPAs are reduced by 0.28 points by having a roommate who drank frequently in the year prior to college and by 0.26 points by having a roommate who drank occasionally (Table 3). This is equivalent to 0.46 standard deviations of a lottery student's college GPA. For comparison, the effect of roommate drinking on college GPA is slightly larger than the effect of a 1/2 point reduction in a student's own high school GPA and is equivalent to the effect of 50 SAT points or 1.2 ACT points in the students' own aptitude test. (This represents about 0.25 standard deviations of the national distribution).[13]

Since our drinking variables were constructed based on a survey in which the students subjectively characterized their drinking during the last year into just three categories: "frequent," "occasional," or "not at all," roommate drinking is likely to be measured with considerable error. The coefficient on this variable may therefore understate the effect of roommate drinking on male students' GPA. In particular, respondents may have had very different views about what constitutes occasional and frequent drinking, and this may account for the similarity of the coefficients on the two variables. Moreover, the standard errors-in-variables problem due to classical measurement error could be exacerbated if students who drink more frequently had a higher subjective threshold for classifying themselves as "frequent" rather than "occasional" drinkers. Given that the coefficients on our two drinking variables (frequent drinking roommate and occasional drinking roommate) were similar, we also ran our regressions grouping the two drinking variables into one. In this regression, the new

[13] We were not able to estimate precisely the effect of floor or building level drinking, but point estimates suggest that a 10-percentage point increase in the proportion of frequent drinkers in the corridor (building) is associated with a 0.03 (0.17) reduction in college GPA.

drinking variable had a very similar coefficient (-0.27) and a very high level of significance (p-value=0.005).[14]

Almost all students stayed enrolled after their first year, and thus remained in our sample. Six students from the lottery sample were not enrolled in 1998, and 26 – approximately 2% of the lottery sample - were not enrolled in 1999. For males, point estimates from probit regressions of a dummy for enrollment on roommate drinking and other controls suggest that having a roommate who drank occasionally prior to college reduces the probability of being enrolled by one percentage point (Table 4). While this effect is large relative to the less than 2% background probability of non-enrollment, it is not statistically significant. Given that the overwhelming majority of students remained enrolled, any attrition bias is likely to be small for mean outcomes.[15]

One possible reason for the difference in results between males and females could be that college-age males are simply more susceptible to peer influences than college-age females. However, there may be some institution-specific factors as well. Since drinking is reportedly more likely to take place in male than female rooms, a male with a drinking roommate is more likely to be exposed to drinking than a female, and will have a harder time avoiding cues or disruption. Moreover, considerable drinking takes place in fraternities, and many first-year students attend a series of parties at fraternities to

[14] This specification check suggests that the results are not due to data mining. Further evidence against the data mining hypothesis is provided by an alternative specification which allows more precise estimation, albeit at the cost of potentially introducing some bias. All of our regressions control for a complete set of housing preference cells, including up to three choices for some of the housing preferences. An alternative approach is simply to control for the first choice on each dimension, i.e. to construct a more relaxed definition of cell by ignoring second and third choices. This provides more degrees of freedom at the cost of potentially introducing some bias. But given that the randomization checks still go through with this more relaxed cell definition, the bias introduced is not likely to be large. When we use the relaxed cell definition that increases the number of observations per cell, the t-statistics on frequent and occasional drinking roommates become –3.2 and –3.62 respectively.

[15] As discussed below, attrition bias may be more substantial at the bottom of the GPA distribution if students with very low GPAs were more likely to drop out.

determine which ones they want to join. Males may be likely to attend fraternity parties together with their first-year roommates.

5. Selection

In many contexts, non-experimental estimates of the correlation between peers would arguably yield stronger correlations than would be found by experimental estimates. This will be the case to the extent that people who are similar on unobservable characteristics choose to associate with each other. In our case, selection seems to operate in the opposite direction. Although males in the lottery sample have lower GPA if their roommate drank in high school, this is not the case in the roommate request sample (Table 5), where students were likely to know each other prior to coming to the university and chose to be roommates. A possible explanation is that students only make it into our sample if they are accepted by the university, and do not matriculate at another university. Within the roommate request sample, any negative effect of peers on academic performance may have already occurred by the time the students apply to college, and therefore would be picked up in admissions and matriculation decisions. Thus, for example, if some students are affected adversely by having close friends who drink heavily and others are not, then those who are adversely affected and perform poorly in high school will not show up in our sample, since they will not have been admitted to the university in the first place.

Regressions of outcomes on outcomes also yield weaker effects in the roommate request sample (Table 6). Point estimates in the lottery sample indicate a positive contemporaneous association between own and roommate GPA, similar to that found by

Sacerdote, although the coefficients here are not statistically significant. Depending on which covariates are included, an increase of one point in roommates' GPA is associated with a 0.045 to 0.124 point increase in own GPA for the whole lottery sample. Among males, a 1-point increase in roommate GPA is associated with a 0.150 to 0.248 point increase in own GPA, depending on covariates.[16] For males in the lottery sample, a one point increase in roommates' average GPA is associated with a 0.248 point increase in one's own GPA, controlling for own high school grades, test scores, parental background, and drinking. For the roommate request sample this coefficient is -0.031. This is consistent with the hypothesis that any peer effects have already been incorporated in the students' high school grades and in the admissions decision.

Selection may also explain why own drinking prior to college is not a stronger predictor of college GPA (see, for example, Table 3). The effect of students' high school drinking may already be picked up in their high-school grades and in the admissions decision. Taken together, these results suggest that selection bias in peer effects models may be quite complicated, potentially being negative as well as positive.

6. Potential Reasons for Effect of Roommate Drinking Prior to College

Several factors could potentially account for the negative effect on males' GPA of being randomly assigned a roommate who drank prior to college. We will not be able to definitively test all potential hypotheses. In particular, the data do not allow us to test

[16] Sacerdote (2001) finds a one point increase in roommates' GPA is associated with a 0.120 (SD=.039) increase in students' own GPA during their freshman year at Dartmouth.

whether students are affected by past roommate drinking or by current drinking.[17] We also cannot completely rule out the possibility that students are influenced by some variable correlated with roommate drinking (rather than by roommate drinking itself), although it is worth noting that the CIRP background survey provides rich information on students' background, attitudes, and behavior, and that we find strong effects of roommate drinking, but no effects for other roommate characteristics, such as frequency of television watching or degree of socializing.[18] Rather than trying to fully exhaust all potential explanations for the roommate drinking effect, we focus on two simple models below. The first focuses on the possible disruptive effect of roommate drinking while the second focuses on peer influence on preferences and on habit formation. In the first model, roommate drinking affects the set of opportunities available to students, since frequent drinking roommates make noise and don't offer help with homework or conversations about Kant over dinner. In the second model, roommate drinking affects student preferences, rather than affecting the set of choices they face.

6.1. A Model of Disruption

Consider a simple model in which students can spend their time in three different types of activity: studying, drinking, or other activities which are not study but do not

[17] In Manski's terminology, this is the inability to distinguish endogenous social interactions from exogenous social interactions. So for example, our study cannot determine whether a program aimed at reducing alcohol drinking on campus will have a multiplier effect.

[18] We found that roommate TV watching and roommate degree of socializing had no significant effect on own college GPA. Furthermore, the effect of roommate drinking continues to be negative and significant even after controlling for roommate TV watching or roommate socializing. We do not have a measure of drug use from the CIRP, but we explored whether the roommate's degree of "partying" prior to college had an effect on college GPA. We found that it did have a negative and significant effect at the 10% level in some specifications, and that the roommate drinking coefficients continued to be negative (and at similar magnitudes as in table 3) but only the occasional drinking roommate coefficient was still statistically significant when we included the roommate partying variable in the regression. We believe that the latter result may be due to students possibly interpreting "partying" as an activity that involves drinking.

disrupt roommate studying (such as listening to music on headphones). Suppose students i and j are roommates. Let p_i denote student i's probability of drinking, q_i the probability of studying, and hence $1 - p_i - q_i$ the probability of doing other things. Suppose that effectiveness in study is reduced by μ by a drinking roommate, for example, because the roommate is noisy when drunk. Alternatively, drinking itself could play no causal role but people who drink could also tend to be noisy or play loud music and watch a lot of TV. Student i's first-year learning is then

$$L_{i1} = q_i(1 - \mu p_j). \tag{1}$$

Thus, student i's learning is reduced by roommate drinking in proportion to the extent student i would otherwise have spent time studying:

$$\frac{\partial L_{i1}}{\partial p_j} = -\mu q_i \tag{2}$$

and

$$\frac{\partial^2 L_{i1}}{\partial q_i \partial p_j} = -\mu . \tag{3}$$

Hence under the pure disruption model, students who themselves drink heavily should be less affected by drinking roommates than students who study heavily. One possible complication is that grades could be a non-linear function of study. If grades are a very concave function of studying, then the negative effect of initial roommate drinking might be greatest for students who don't spend much time studying (for whom the marginal effect of learning on grades is highest). However, it seems unlikely that the concavity would be strong enough to offset the fact that students who spend little time studying in any case are unlikely to have their study disrupted by roommate drinking.

If roommates stay together in their second year with exogenous probability α and the choice of a sophomore-year roommate is otherwise independent of the first-year roommate, second-year learning is

$$L_{i2} = C_i + \alpha q_i (1 - \mu p_j) \tag{4}$$

where C_i is a constant reflecting the expected amount of learning student i would achieve with a new roommate. In this case,

$$\frac{\partial L_{i2}}{\partial p_j} = -\alpha \mu q_i . \tag{5}$$

Data from a survey of students in later entering classes (1998-2000) suggest that about 17% of students randomly assigned roommates through the housing lottery remain with their roommate for more than two semesters. Setting $\alpha = 0.17$, this simple disruption model thus implies that the effect of initial roommate assignment on second-year grades should be 17% of the effect on first-year grades.

To the extent that some second-year courses build on material covered in first-year courses, failure to learn during the first year could reduce capacity to learn during the second year and thus hypothetically the negative effect of disruption by the assigned freshman year roommate on second-year grades could be more than 17% as large as the effect on first-year grades. However, while at least 25% of second-year courses have a first-year prerequisite, the effect of initial assignment to a drinking roommate on second year grades in classes for which there is a prerequisite is actually insignificantly positive, while that in subjects without prerequisites is strongly negative. (We also find no evidence that the extent of drinking by the initially assigned roommate affects whether people take classes with prerequisites). Thus it seems that even a somewhat richer model

which allowed for cumulative learning would suggest a much smaller effect of initial roommate drinking on second-year grades than first-year grades.

The disruption model also suggests that even in a sample of students who self-select roommates, students with drinking roommates should obtain lower GPAs conditional on pre-college academic performance and admissions decisions. This is because even if the student socialized with his future roommate prior to college, the drinking would be more likely to disrupt study when the students are roommates than when they live at home, and hence the impact of the future roommate would not have been reflected in grades prior to college.

In summary, the pure disruption model suggests that 1) assignment of a drinking roommate should most seriously affect students who spend a lot of time studying and would otherwise have done well in school; 2) as a corollary, students who drink should be less affected by roommate drinking than students who do not drink themselves; 3) the effect of first-year roommate assignment on second-year grades should be approximately 0.17 times the effect of first year roommate assignment on first year grades; and 4) assignment to a drinking roommate should be negatively correlated with college GPA even in a self-selected sample.

6.2. A Model of Habit Formation and Peer Effects

Having a drinking roommate could also potentially affect academic performance through peer effects in preferences and through habit formation. The medical and psychological literature suggests that alcoholism, which affects around 15% of the U.S. population, has a strong genetic component but that it also responds strongly to

environmental influences. More generally, alcohol consumption has cumulative effects on all drinkers (Gardner and Lowinson [1993], Beatty *et al.* [2000], National Institute of Alcohol Abuse and Alcoholism [2001]).

Suppose that students are endowed initially with an idiosyncratic drinking propensity $d \in (0,1)$. This could reflect either genetic susceptibility or the students' environment prior to college. Student i (with propensity d_i) obtains instantaneous utility

$$U_{it} = d_i[X_{it} + CX_{it}X_{jt} + DX_{it}X_{it-1}] - \frac{1}{2}X_{it}^2 \tag{6}$$

from drinking an amount X_{it} at time t. Here X_{jt} is the roommate's drinking, $C \in [0,1)$ and $D \geq 0$.[19] The terms in this equation may be interpreted as follows: $d_iX_{it} - \frac{1}{2}X_{it}^2$ is a standard concave function incorporating both the utility of consumption and the disutility of expenditure on alcohol. The C term captures peer effects under which students wish to drink more if their roommate drinks more. The D term captures the possibility that students who drank more last year may want to drink more this year. The form of our utility function thus allows for the possibility that past drinking (X_{it-1}) and present drinking (X_{it}) are complements, and for the possibility that peer drinking (X_{jt}) is complementary with own drinking (X_{it}). The complementarity between past and present drinking could represent either physical or psychological addiction or simply increased alcohol tolerance. A process of reinforcement of past positive experiences can increase

[19] The coefficient on the quadratic term is simply a normalization, while the restrictions on the size of C and d_i are required to guarantee the existence of an equilibrium. The assumption that a single student-specific term, d_i, multiplies the entire term in brackets allows students to vary only along one dimension, and is an analytical simplification; obviously in reality variation occurs along several dimensions. We simply require correlation along these dimensions.

current desire to drink.[20] Complementarity between roommate drinking and own drinking similarly occurs if seeing others drink may be a cue which triggers cravings for drinking. Laibson's [2001] cue-theory of consumption offers a microfoundation for both types of complementarity. We assume that students with greater drinking propensity are more susceptible to addiction and more sensitive to cues from peer drinking.

We consider a three period model (t=0, 1, 2, representing high school, first year of college and second year of college). Each period each student i maximizes his utility from alcohol consumption, taking X_{it-1} and X_{jt} as given; we consider "naïve" students who do not consider the effect of today's alcohol consumption on preferences for future drinking in deciding how much to consume today.[21]

In period 0, students are in high school and have no roommate. Student i chooses X_{i0} to maximize $d_i X_{it} - \frac{1}{2} X_{it}^2$. Hence $X_{i0} = d_i$. In period 1, the first year of college, student i's best response function is of the form

$$X_{it} = d_i(1 + CX_{jt} + DX_{it-1}) \tag{7}$$

and in a Nash equilibrium with roommates choosing drinking simultaneously, student i chooses drinking

$$X_{it} = \frac{d_i(1 + DX_{it-1} + Cd_j(1 + DX_{jt-1}))}{1 - C^2 d_i d_j}., \tag{8}$$

with a symmetric formula for X_{jt}. Thus for C>0 alcohol consumption is higher, *ceteris paribus*, if roommate drinking is high or, assuming D>0, if alcohol consumption was

[20] Singleton and Gorelick [1998]. The reinforcement process may involve permanent neurological change (Anton [1999]).

[21] We expect that similar qualitative results would obtain if students place small enough nonzero weight on future outcomes when making drinking decisions.

high in the previous period.[22] Note that if D>0 and C>0, $\frac{\partial X_{it}}{\partial X_{it-1}} > 0$ and $\frac{\partial X_{it}}{\partial dX_{jt-1}} > 0$:

both own and roommate past drinking increase equilibrium drinking (because of the complementarities between past and present drinking and between own and roommate drinking). Finally $\frac{\partial X_{it}}{\partial d_j} > 0$: increasing d_j increases the marginal benefit to the roommate from own drinking, and since roommate drinking and own drinking are complements, this increases own drinking.

Now suppose that student learning is given in each period by

$$L_{it} = \overline{L}_{it} - \gamma X_{it} \tag{9}$$

where $\overline{L}_{it}$ is total potential learning.[23]

The total effect of roommate initial drinking d_j on own learning operates through several channels since d_j affects X_{j0} (= d_j) as well as the parameters of the roommate's utility function. Using the chain rule,

$$\frac{dL_{i1}}{dd_j} = -\gamma\left(\frac{\partial X_{i1}}{\partial d_j} + \frac{\partial X_{i1}}{\partial X_{j0}}\right) \tag{10}$$

[22] Note that it is not relevant to apply this model for habit formation for many repetitions or to consider steady states of the process as t gets large. This is because X_{it} may get very large for students susceptible to habit formation (D_i positive) because of the presence of the X_{it-1} term. We think of t as being small (students are observed for at most three years).

[23] There is strong physiological, psychological and neurological support for alcohol-induced learning impairment (Parsons [1998], Oscar-Berman *et al.* [1997], Parsons and Nixon [1998], Beatty *et al.* [2000]). The functional form of the relationship between drinking and learning impairment (and between learning and grades) is less clear. Linearity is assumed as in the disruption model for simplicity. Physiological evidence (Evert and Oscar-Berman [1995], Parsons and Nixon [1998]) suggests the true relationship may be concave, with the marginal effect increasing for higher consumption levels and the total effect increasing with cumulative lifetime consumption. Incorporating this in our model would not change the basic results and would reinforce the result that the most severe effects occur for frequent drinkers.

$$\begin{aligned}\frac{dL_{i2}}{dd_j} &= -\gamma\left(\frac{\partial X_{i2}}{\partial d_j}+\frac{\partial X_{i2}}{\partial X_{i1}}\frac{dX_{i1}}{dd_j}+\frac{\partial X_{i2}}{\partial X_{j1}}\frac{dX_{j1}}{dd_j}\right)\\ &= -\gamma\left(\frac{\partial X_{i2}}{\partial d_j}+\frac{\partial X_{i2}}{\partial X_{i1}}\left(\frac{\partial X_{i1}}{\partial d_j}+\frac{\partial X_{i1}}{\partial X_{j0}}\right)+\frac{\partial X_{i2}}{\partial X_{j1}}\left(\frac{\partial X_{j1}}{\partial d_j}+\frac{\partial X_{j1}}{\partial X_{j0}}\right)\right)\end{aligned} \tag{11}$$

Because of the multiple effects, explicit formulae for these partial derivatives are too complicated to be useful. However, it is easy to check that all the partial derivatives are positive, so learning in both the first and second year of university is negatively affected by roommate drinking prior to college. Moreover, because of the complementarities in drinking across students and across periods, it is also clear that these effects are increasing in both roommate drinking propensity and own drinking propensity (so empirically we will observe the greatest effect on learning for frequent drinking students with frequent drinking roommates).

Note also that under the model, the effect of initial roommate assignment may grow over time even if roommates do not all stay together. To see this observe first that if roommates stay together then $X_{i2} > X_{i1} > X_{i0} = d_i$ and $X_{j2} > X_{j1} > X_{j0} = d_j$. (It is immediate that $X_{i1} > d_i$ and $X_{j1} > d_j$. Then since $X_{i1} > X_{i0}$, $X_{j1} > X_{j0}$ and X_{it} and X_{jt} are increasing in X_{it-1} and X_{jt-1}, it follows immediately that $X_{i2} > X_{i1}$ and $X_{j2} > X_{j1}$). Since $\frac{\partial X_{it}}{\partial d_j}$ is increasing in X_{it-1} and X_{jt-1} it follows that $\frac{\partial X_{i2}}{\partial d_j} > \frac{\partial X_{i1}}{\partial d_j}$. Next observe that $\frac{\partial X_{i2}}{\partial X_{j1}} = \frac{\partial X_{i1}}{\partial X_{j0}} = \frac{CDd_i d_j}{1-C^2 d_i d_j}$ and $\frac{dX_{j1}}{dd_j} > \frac{\partial X_{j1}}{\partial d_j} > 1 = \frac{dX_{j0}}{dd_j}$. Thus if two roommates stay together then

$$\begin{aligned}\frac{dL_{i2}}{dd_j} &= -\gamma\left(\frac{\partial X_{i2}}{\partial d_j}+\frac{\partial X_{i2}}{\partial X_{i1}}\frac{dX_{i1}}{dd_j}+\frac{\partial X_{i2}}{\partial X_{j1}}\frac{dX_{j1}}{dd_j}\right)\\ &< -\gamma\left(\frac{\partial X_{i1}}{\partial d_j}+0+\frac{\partial X_{i1}}{\partial X_{j0}}\frac{dX_{j0}}{dd_j}\right)=\frac{dL_{i1}}{dd_j}\end{aligned} \tag{12}$$

so the effect of initial roommate drinking on learning grows over time. Given that not all roommates stay together, overall the effect of initial roommate assignment may either grow or shrink over time.

The model of habit formation and peer effects in preferences implies that 1) the negative effect of roommate pre-college drinking on own GPA will be greatest for those who themselves drank in high school; 2) the effect of initial roommate assignment may either grow or shrink over time; and 3) students assigned roommates who drank more prior to college should drink more in college. The next section tests some of these implications.

7. Characterizing the Effect of Roommate Drinking

This section further explores the effect of initial roommate assignment on males' GPA. It argues that effects are not uniform, but concentrated on the bottom of the GPA distribution; that they persist over time; and that they are particularly strong for those who themselves drank frequently prior to college. Taken together, these facts are more consistent with a model of habit formation and peer effects in preferences than with a disruption model.

7.1. Effect on Distribution of GPA

Roommates' drinking does not seem to simply cause a uniform downward shift in males' GPA, but rather to greatly reduce the lower tail of GPA, to somewhat decrease median GPA, and to have a smaller impact on the upper tail of GPA (Table 7). For example, having a roommate who drinks occasionally reduces the 10th percentile of GPA by 0.5 points with a t-statistic of more than 2.5, but has an insignificant effect of -0.05 on the 90th percentile of GPA.[24] The effect at the bottom of the distribution may be in fact underestimated due to attrition bias, since the dropout rate is higher for males who were assigned roommates who drank frequently in high school. There is little interaction between having a roommate who drinks and predicted entering GPA based on a student's own academic background variables. This suggests that the large effects at the lower quantiles are not due to a particularly adverse effect of drinking roommates on students with low predicted GPA, but rather to large impacts on some students and weaker impacts on others. It also suggests that the results may generalize beyond the particular type of student at this university and are potentially relevant to less selective institutions.

Note that the large effect at the bottom of the distribution of GPA is consistent with the hypothesis that a few students are badly affected by roommate drinking, as might be the case if some students are more vulnerable to addiction than others, for genetic or other reasons. In contrast, the disruption model suggests that effects should be strongest for students who study frequently, and thus that effects should, if anything, be concentrated at the top of the distribution.

[24] The results should be interpreted with caution since GPA is an ordinal, rather than a cardinal, measure, and since the maximum possible GPA is 4.0.

7.2. Dynamics of peer effects

Male students whose roommates were frequent drinkers in high school have GPAs 0.18 points lower in their first year and 0.43 points lower in their second year (Table 8). This suggests that peer effects persist, and possibly even grow from the first to second year of university, although it is worth bearing in mind the difference between the two coefficients is not statistically significant.[25]

As noted earlier, only about 17% of students live with their initial randomly assigned roommate for more than 2 semesters.[26] If the disruption theory was the only force at work, so that habit formation played no role and so that students who no longer shared a room with their first-year roommate during their second year were no longer affected by these roommates, we would observe the negative peer effects from alcohol consumption fade over time as students move away from the disruptive environment. But, as indicated earlier, the effects persist in the second year. Furthermore, contrary to the prediction of the disruption model, we tested and rejected the hypothesis that the second year effect is equal to the first year effect multiplied by the proportion of students who stayed together in their second year (0.17). The persistence of the effect of initial assignment to a drinking roommate is consistent with the model of habit formation.

Together with Johanne Boisjoly, Greg Duncan, and Jacque Eccles, we recently obtained data which will allow us to look at longer term effects of roommate drinking. Dropout rates are greater over this longer period, and hence bias is more of a concern in

[25] To test whether the difference is significant or not, we ran a fixed-effect regression at the cell level where the dependent variable is the difference between second-year GPA and first-year GPA. Augmenting the regression with the option "cluster" in Stata at the room level means that there is no a priori restriction on the error structure at the room level. We find that the coefficient of the frequent drinking roommate variable is large but not estimated precisely resulting in a p-value of 0.15.

looking at longer-run outcomes. However, in preliminary analysis in which students who drop out are treated as having the GPA associated with their final semester in residence, point estimates suggest that the effect of initial assignment to a roommate who drank frequently prior to college is quite persistent over time, although significant levels drop. Point estimates also suggest that the effect of initial assignment to a roommate who drinks occasionally moderates over time, although the estimated effects remain large. These data will be analyzed further in future work.

Another factor that may explain the persistence of peer effects over time could be cumulative peer selection along the lines of Akerlof [1997]. Suppose that once one starts associating with a particular person, one becomes more similar to that person. One then chooses other peers who are similar to the original peer and the process repeats itself and intensifies. For example, a student who is assigned a first-year roommate who drinks may also interact with other students in the same residence hall who do not drink much, and hence may drink only moderately during the first year of college. But the roommate may move into a fraternity his sophomore year, and if the student follows, the student's peers in sophomore year may drink even more than in freshman year. However, we find only weak evidence that students randomly assigned roommates who drank prior to college were more likely to join fraternities. About 21% of male students who were assigned roommates who drank frequently in high school joined fraternities, compared to 16% of those who were assigned roommates who did not drink in high school. However, this difference was not statistically significant.

[26] Based on a survey administered in the winter of 2002 to a sample of students who entered the university in 1998-

7.3. Interaction Between Own and Roommates' High School Drinking

For male students who drank frequently in high school, having a roommate who also drank frequently is associated with a particularly sharp decline in GPA (Table 9). The last column of Table 9, which reports results from a regression run only on males who drank frequently, suggests that having a roommate who drank frequently is associated with a 0.99 point lower GPA. An analysis using the whole lottery sample to estimate interactions between own and roommate drinking also suggests that frequent drinkers are significantly more strongly influenced by frequent-drinking roommates than are occasional drinkers, but the implied effect of a frequent-drinking roommate on a frequent-drinking student's GPA is smaller (around 0.67).[27]

The particularly high susceptibility of frequent-drinking students to frequent-drinking roommates is consistent with our second model. The subset of the population with high drinking propensity is more vulnerable to high drinking roommates, and is also likely to have drunk more in high school.

We did not find any evidence that susceptibility to drinking roommates varied by characteristics other than sex and pre-college drinking. For example, there is no evidence that religious students were less subject to influence by roommate drinking or that the degree of similarity of roommates, as reflected in the number of similar responses to the

2000 and who were randomly assigned to their first-year roommate.

[27] This specification allows for nine possible interactions between own drinking (frequent, occasional, none) and roommate drinking (frequent, occasional, none) and omits the interaction between non-drinker and frequent drinking roommate. The drawback of using this specification relative to the one reported in Table 9 is that it assumes that the other explanatory variables (own and roommate academic background, own and roommate parental background, and test dummies) have the same effect on college GPA for frequent drinkers as for occasional drinkers and for non-drinkers. The advantage is that it uses a larger sample, which should increase the precision of our estimates. In the regression with interactions the coefficient of frequent drinker interacted with frequent drinking roommate is –0.40 with a t-statistic of –

CIRP questionnaire, affected the strength of peer effects. However, our inability to find these effects may be due to our small sample size.

In our main sample, we do not have data on students' subsequent drinking or in fact, any outcome data other than registrar data. However, in ongoing work with Johanne Boisjoly, Greg Duncan, and Jacque Eccles, we are administering surveys to several cohorts of entering students. Preliminary evidence from these surveys suggests that students assigned to roommates who reported drinking in the year prior to entering college are more likely to drink after the first year of college. We find that 59% of male students who were assigned a frequent drinking roommate the first year reported drinking alcohol more than once a week, compared to 39% of those who were assigned a non-drinking roommate (Table 10). Similarly, 94% of males who were assigned to a frequent drinking first-year roommate report ever having been involved in binge drinking, compared to 81% of those assigned a non-drinking first-year roommate. However, preliminary work suggests that the statistical significance of these differences is sensitive to the choice of econometric specification.

Taken as a whole, the results presented in this section are more consistent with the hypothesis that roommates influence each other's preferences than with the hypothesis that roommates who drink are disruptive, altering students' choice sets. First, counter to a simple disruption model, students who themselves drank frequently in high school are particularly susceptible to roommates who drank. Also counter to the disruption model, the roommate effect is concentrated in the bottom quantiles of the GPA distribution. Third, the effects of initial roommate assignment persist during the second year although

2.02, confirming that having a frequent drinking roommate has a substantially higher effect for frequent

only 17% of students lived with their first-year roommate after the first year. Finally, the fact that students assigned to roommates who reported drinking in the year prior to entering college are more likely to drink after the first year of college is more consistent with the model of peer effects and habit formation than with the disruption model. Table 11 summarizes why we tend to favor the peer effects and habit formation hypothesis over the disruption hypothesis.

8. The Effect of Sorting on Average GPA

The finding in Section 7.3 that males who drank frequently in high school are particularly susceptible to roommates who drank frequently implies that the way in which roommates are matched together will affect average GPA in the university. Assuming that the estimated coefficients for roommates' high school drinking listed in Table 9 are the true peer effects on a student's college GPA, matching two frequent drinkers together and two non- drinkers together yields an average overall GPA 0.36 points lower than matching frequent drinkers and non-drinkers together (Table 12). Positive assortative matching, in which students with similar drinking habits are matched together, would reduce average GPA within the lottery sample by 0.065 points relative to random assignment. Negative assortative matching, in which frequent drinkers are matched with non-drinkers, increases average GPA by 0.024 points relative to random assortment.[28]

drinkers than for non-drinkers.

[28] Of course, people might not report their drinking habits accurately if the university sorts them on the basis of self-reporting drinking. Moving from positive assortative matching to random assignment has a much bigger effect on average GPA than moving from random assignment to negative assortative matching, because frequent drinkers are particularly susceptible to being paired with other frequent drinkers. Since only 15% of students at the university drank frequently in high school, only .15 x .15 = 2.25% of roommate groups combine two frequent drinkers under random

Many universities have responded to alcohol problems by allowing students to choose substance-free housing. Substance-free housing may affect GPA through a variety of channels. For example, students in substance-free housing may feel more pressure not to drink. However, a side effect of this policy is that students who do not choose substance-free housing will be concentrated together in "regular" residence halls. If the only way in which substance-free housing affected GPA was through its influence on the drinking background of roommates, eliminating the substance-free housing option and randomizing these students in with the general population would lower the GPA of students who chose substance-free housing by 0.06 points. However, it would raise aggregate GPA among other students by 0.1 points for each student moved out of substance-free housing. Thus, overall, eliminating substance-free housing would raise overall GPA by 0.04 points per student currently in substance-free housing. (Universities, may, of course, be pursuing objectives other than maximizing average GPA).

Of course, substance-free housing could potentially affect GPA in ways other than by influencing roommate assignment, but we find no evidence for any positive impacts. Since substance-free housing is not assigned randomly, it is difficult to isolate treatment effects, but OLS estimates suggest that substance-free housing is negatively associated with GPA among women, and insignificantly positively associated with GPA among men if one does not condition on how substance-free housing affects roommate assignment (Table 12, Columns 1,2,5, and 6). Conditioning on roommate assignment, the positive

matching and hence moving from random matching to negative assortative matching does not break up many roommate pairs in which both members are frequent drinkers. In a student population with more frequent drinkers (such as the one perhaps present at a less academically competitive university), random matching would create more pairs of frequent drinkers and the benefits of negative assortative matching would be greater. National figures are not available on our composite drinking variable, which includes drinking of both beer and wine/liquor, but in this university 56% of students drink beer frequently or occasionally prior to coming to college compared to a national

effect on males basically disappears, and the negative effect on women remains but is slightly weaker (Table 12, columns 3 and 7). There is little evidence that male students who live in substance-free residence halls are less susceptible to roommates' high school drinking, but some evidence this may be the case for females (Table 12, Columns 4 and 8). It may seem surprising that some students who reported drinking frequently during high school chose substance-free housing, but the choice of substance-free housing does not necessarily indicate that the student does not plan to drink since some parents may insist that their children choose substance-free housing.

7 – Conclusions

Evidence from a large state university in which some students are assigned roommates randomly using a lottery suggests that males' GPA is reduced by more than a quarter point by having a roommate who drank prior to college. This effect is equivalent to almost half a standard deviation of a student's GPA (for the lottery sample) and slightly larger than the effect of a 1/2 point increase in a student's own high school GPA. The roommate drinking effects are larger for students in the lowest quantiles of the college GPA distribution and for those students who reported drinking frequently in high school. The effects seem to persist over time. Male students whose roommates were frequent drinkers in high school have GPAs 0.18 points lower in their first year and 0.43 points lower in their second year, although the difference in these coefficients is not statistically significant. We find no significant effect for females.

average of 53%, and 64% of students drink wine or liquor frequently prior to coming to college compared to a national average of 57%.

The results are more consistent with the hypothesis that roommates influence each other's preferences than with the hypothesis that roommates who drink are disruptive, altering students' choice sets. First, counter to a simple disruption model, students who themselves drank frequently in high school are particularly susceptible to roommates who drank. Also counter to the disruption model, the roommate effect is concentrated in the bottom quantiles of the GPA distribution. Third, the effects of initial roommate assignment persist during the second year although only 17% of students lived with their first-year roommate after the first year.

It is natural to ask whether some of these results can be generalized more broadly to other settings, such as secondary schools. On the one hand, college students are older and hence may be less subject to peer influences. But on the other hand, college students generally live away from home and hence may be more subject to peer influences. Overall, it seems difficult to predict whether peer effects would be larger or smaller among younger students.

We find that peer effects are related to roommate behavior (drinking) but not to socio-economic background or academic ability. In this context, this seems to suggest that attempts to improve outcomes for at-risk students should perhaps focus not so much on peers' academic ability or socio-economic status, but on problem behavior. One option some universities have adopted is removing students with problem behavior from the environment, but given that our analysis suggests that segregating people who drink together may be particularly problematic, this may be good for those who segregate themselves, but it potentially worsens outcomes for society as a whole. Interventions

aimed at directly reducing problem drinking may be more promising, although more evidence would be needed to establish this.

References

ACT National and State Scores: The 1997 ACT High School Profile Report –National Normative Data. Available at: http://www.act.org/news/data/97/t1.html

Akerlof, George. 1997. Social Distance and Social Decisions. *Econometrica* 65(5): 1005-27.

Akerlof, George and Rachel Kranton. 2000. Economics and Identity. *Quarterly Journal of Economics* 115(3): 715-753.

Anton, R.F. 1999. What is craving? Models and implications for treatment. *Alcohol Research & Health* 23(3): 165–173.

Barron's Profiles of American Colleges. 2000. Hauppage, NY: Barron's Educational Series, Inc.

Beatty, W.W.; Tivis, R.; Stott, H.D; Nixon, S.J.; and Parsons, O.A. 2000. Neuropsychological deficits in sober alcoholics: Influences of chronicity and recent alcohol consumption. Alcohol Clin Exp Res 24(2): 149-154.

Becker, Gary S; Michael Grossman, and Kevin M Murphy. 1994. An Empirical Analysis of Cigarette Addiction. *American Economic Review* 84(3): 396-418.

Blimling, G.S. 1993. The influence of college residence halls on students. *Higher Education: Handbook of Theory and Research* 9: 248-307.

Evert, D.L., and Oscar-Berman, M. 1995. Alcohol-related cognitive impairments: An overview of how alcoholism may affect the workings of the brain. Alcohol Health Res World 19(2): 89-96.

Gardner, E.L. & Lowinson, J.H. 1993. Drug craving and positive/negative hedonic brain substrates activated by addicting drugs. Seminars in the Neurosciences 5: 359-368.

Kandel, Denise B. 1980. Drug and Drinking Behavior Among Youth. *Annual Review of Sociology* 6: 235-285.

Laibson, David. 2001. A Cue-Theory of Consumption. *Quarterly Journal of Economics* 116(1): 81-120.

Mooney, Debra K., and Brenda O. Gilbert. 1999 Predicting alcohol consumptions: The influences of perceived opposite-sex peer expectancies and drinking behavior. *Journal of Child and Adolescent Substance Abuse.* 9(1): 73-84.

National Institute on Alcohol Abuse and Alcoholism. Alcohol Alert No. 54 (October 2001): Craving Research: Implications for Treatment. http://www.niaaa.nih.gov/publications/aa54.htm).

Norton, E.C., R.C. Lindrooth, and S.T. Ennett. 1998. A Method to Control for Endogeneity in Estimating Peer Group Effects on Adolescent Alcohol and Tobacco Use. Health Economics, 7(5): 439-53.

Oscar-Berman, M.; Shagrin, B.; Evert, D.L.; and Epstein, C. 1997. Impairments of brain and behavior: The neurological effects of alcohol. Alcohol Health Res World 21(1): 65-75.

Parsons, O.A. 1998. Neurocognitive deficits in alcoholics and social drinkers: A continuum? Alcohol Clin Exp Res 22(4): 954-961.

Parsons, O.A., and Nixon, S.J. 1998. Cognitive functioning in sober social drinkers: A review of the research since 1986. J Stud Alcohol 59(2): 180-190.

Pommerich, M., B. A. Hanson, D.J. Harris, and J.A. Sconing. 2000. Issues in creating and reporting concordance results based on equipercentile methods. *ACT Research Report Series* (January).

Sacerdote, Bruce. 2001. Peer effects with random assignment: results for Dartmouth roommates. *Quarterly Journal of Economics* 116(2): 681-704.

Singleton, E.G., and Gorelick, D.A. 1998. Mechanisms of alcohol craving and their clinical implications. In: Galanter, M., ed. Recent Developments in Alcoholism, Vol. 14: *The Consequences of Alcoholism*. New York: Plenum Press. pp. 177–195.

US News and World Report's America's Best Colleges 2002 rankings. Washington, D.C.

Wechsler, Henry, Jae Eun Lee, Meichun Kuo, and Hang Lee. 2000. College Binge Drinking in the 1990s: A Continuing Problem - Results of the Harvard School of Public Health 1999 College Alcohol Study. *Journal of American College Health* 48(10): 199-210.

Zimmerman, David J. 1999. Peer Effects in Academic Outcomes: Evidence from a Natural Experiment Discussion paper No. 52, Williams Project on the Economics of Higher Education, Williams College.

Table 1 – Descriptive Statistics

	Lottery sample	Whole sample	Roommate request sample
Academic background			
Admissions test score (standardized)	-0.03	0.00	**-0.11**
	(0.86)	(1.00)	(0.97)
High school GPA	3.61	**3.56**	3.60
	(0.40)	(0.44)	(0.42)
Parental background			
Father's years of schooling	16.30	16.23	**16.06**
	(2.10)	(2.21)	(2.25)
Mother's years of schooling	15.68	15.68	15.57
	(2.20)	(2.22)	(2.17)
Parental income (in 000's of $)	120.01	119.05	118.25
	(74.75)	(79.37)	(76.19)
Drinking background			
Drank frequently in high school (all)	0.15	0.15	0.18
Drank frequently in high school (males)	0.16	0.17	0.20
Drank occasionally in high school (all)	0.53	0.51	**0.49**
Drank occasionally in high school (males)	0.51	0.48	**0.44**
Demographics			
Females	0.55	**0.51**	**0.45**
Blacks	0.03	**0.07**	**0.10**
Academic Outcomes			
Cumulative GPA 1999	3.10	**2.94**	**3.01**
	(0.56)	(0.87)	(0.73)
Cumulative credits 1999	46.57	**40.32**	**36.27**
	(14.73)	(17.32)	(14.37)
Housing preferences			
Substance-free hall	0.32	0.34	0.3
Smoker	0.06	0.06	**0.09**
Single room	0.02	**0.09**	**0.02**
Double room	0.86	**0.80**	0.88
Triple room + economy	0.12	0.11	0.1
Living learning center	0	**0.25**	**0.22**
Number of observations	1357	7541	1052

Means in bold are significantly different from the lottery sample means at 5% significant level.

Standard deviations for non-dummy variables reported in parentheses

Note: The number of observations in the lottery and roommate request samples do not add up to the number of observations in the whole sample because many students did not meet the lottery deadline (and hence were assigned non-randomly) and did not choose a particular roommate.

Table 2- Effect of Roommates' Background on Cumulative GPA at the End of Summer 1999. Lottery Sample

	Specification				
	(1)	(2)	(3)	(4)	(5)
Roommates' academic background					
Roommates' avg. standardized test score	0.007	0.023	0.025	.018	0.025
	(0.035)	(0.038)	(0.041)	(.039)	(0.040)
Roommates' avg. high school GPA	-0.043	0.004	0.031	-.052	0.017
	(0.078)	(0.082)	(0.089)	(.089)	(0.090)
Roommates' parental background					
Roommates' avg. father's education			0.016	-.006	0.011
			(0.020)	(.019)	(0.020)
Roommates' avg. mother's education			0.005	.003	0.006
			(0.017)	(.017)	(0.017)
Roommates' avg. parental income			0.146	.001	0.210
			(0.407)	(.000)	(0.412)
Roommates' high school drinking					
Frequent				-.173	-0.104
				(.089)	(0.093)
Occasional				-.132	-0.132
				(.073)	(0.073)
Student's academic background					
Standardized admission test score		0.093	0.114*		0.112*
		(0.038)	(0.042)		(0.043)
High school GPA		0.475*	0.440*		0.442*
		(0.077)	(0.082)		(0.082)
Student's parental background					
Father's education		0.031	0.030		0.028
		(0.019)	(0.019)		(0.019)
Mother's education		-0.007	-0.002		-0.001
		(0.015)	(0.015)		(0.015)
Parental income		0.295	0.300		0.342
		(0.371)	(0.397)		(0.404)
Student's high school drinking					
Frequent				-.128	-0.070
				(.091)	(0.096)
Occasional				-.045	-0.046
				(.070)	(0.076)
Observations	1298	1104	1013	1183	1011
R^2	0.549	0.619	0.638	.576	0.642
Adjusted R^2	0.078	0.192	0.216	.099	0.218

Robust standard errors in parentheses. * significant at 5% level.
Parental income is measured in millions of dollars.
Huber-White standard errors were calculated using roommate clusters. Dummy variables for cells and type of admission tests included in all regressions.

Table 3- Effect of Roommates' Background Characteristics on Cumulative GPA at the End of Summer 1999, by Sex.

	Whole lottery sample	Sub-sample	
		Females	Males
Roommates' high school drinking			
Frequent	-0.104	0.118	-0.282*
	(0.093)	(0.126)	(0.128)
Occasional	-0.132	-0.008	-0.263*
	(0.073)	(0.103)	(0.101)
Student's high school drinking			
Frequent	-0.070	-0.032	-0.109
	(0.096)	(0.124)	(0.150)
Occasional	-0.046	-0.029	-0.028
	(0.076)	(0.093)	(0.119)
Observations	1011	555	456
R^2	0.642	0.706	0.595
Adjusted R^2	0.218	0.272	0.173

Robust standard errors in parentheses.
* significant at 5% level. Huber-White standard errors were calculated using roommate clusters.
Controls for student's and roommate's academic background (high school GPA and admissions test scores), student's and roommate's parental background (father's education, mother's education, parental income), type of admission tests, and dummy variables for cell included in all regressions.

Table 4- Effect of Roommates' and Own Drinking on Probability of Non-Enrollment Probit Regressions Using the Lottery Sample

	Dummy for Non-Enrollment	
	Males and females	Males only
Roommates' high school drinking		
Frequent	-0.039	-.123
	(0.315)	(.442)
	[-0.001]	[-.001]
Occasional	0.288	.418
	(0.231)	(.298)
	[0.010]	[.012]
Student's high school drinking		
Frequent	0.094	.017
	(0.270)	(.359)
	[0.004]	[.003]
Occasional	-0.045	-.094
	(0.207)	(.305)
	[-0.002]	[-.001]
Observations	1013	458
χ^2	40.08	61.93
Prob > χ^2	0.001	0.000

Robust standard errors are reported in parentheses. Marginal effects are reported in brackets.
* significant at 5% level. Huber-White standard errors were calculated using roommate clusters.
The mean of the non-enrollment dummy is 0.0278.
Controls for student's and roommate's academic background (high school GPA and admissions test scores), student's and roommate's parental background (father's education, mother's education, parental income), type of admission tests, and dummy variables for cell included in all regressions.

Table 5- Determinants of Cumulative GPA at the End of Summer 1999. Lottery Sample vs. Roommate Request Sample (males only)

	Lottery sample	Roommate request sample
Roommates' high school drinking		
Frequent	-0.282*	0.018
	(0.128)	(0.155)
Occasional	-0.263*	-0.082
	(0.101)	(0.114)
Roommates' parental background		
Roommates' avg. father's education	0.017	-0.047
	(0.032)	(0.033)
Roommates' avg. mother's education	0.003	-0.025
	(0.023)	(0.034)
Roommates' avg. parental income	0.318	0.953
	(0.629)	(0.801)
Roommates' academic background		
Roommates' admission test score	0.077	0.016
	(0.059)	(0.062)
Roommates' avg. high school GPA	-0.158	0.075
	(0.154)	(0.150)
Student's high school drinking		
Frequent	-0.109	0.033
	(0.150)	(0.158)
Occasional	-0.028	-0.133
	(0.119)	(0.123)
Observations	456	452
R^2	0.595	0.629
Adjusted R^2	0.173	0.283

Robust standard errors in parentheses. * significant at 5% level.
Parental income is measured in millions of dollars.
Huber-White standard errors were calculated using roommate clusters. Dummy variables for cells and type of admission tests included in all regressions.

Table 6 - Contemporaneous Correlation of GPA
Lottery Sample vs. Roommate Request Sample

	College GPA for Males	
	Lottery sample	Roommate request sample
Roommates' average college GPA	0.248	-0.031
	(0.157)	(0.358)
Student's academic background		
Standardized admission test score	-0.003	-0.002
	(0.080)	(0.251)
High school GPA	0.383*	0.932
	(0.179)	(0.621)
Student's parental background		
Father's education	0.074	0.001
	(0.045)	(0.136)
Mother's education	-0.031	-0.143
	(0.041)	(0.104)
Parental income	-0.000	0.002
	(0.001)	(0.003)
Student's high school drinking		
Frequent	0.204	-0.248
	(0.208)	(0.651)
Occasional	0.048	-0.292
	(0.147)	(0.391)
Observations	244	247
R^2	0.760	0.842
Adjusted R^2	0.329	0.099

Robust standard errors in parentheses. * significant at 5% level.
Huber-White standard errors were calculated using roommate clusters. Dummy variables for cells and type of admission tests included in all fixed-effects regressions. Sample is restricted to unique pairs (i.e. roommate pairs are not allowed to appear more than once in the sample).

Table 7- Effect of Roommate Drinking on Distribution of GPA. Males from Lottery Sample.

	Quantiles				
Quantile	10%	25%	50%	75%	90%
Frequent drinking roommate	-0.50*	-0.37*	-0.33*	-0.30*	-0.24
	(0.15)	(0.17)	(0.15)	(0.12)	(0.15)
Occasional drinking roommate	-0.53*	-0.35*	-0.13	-0.09	-0.05
	(0.20)	(0.14)	(0.12)	(0.11)	(0.14)
GPA associated with quantile (for students with non-drinking roommates)	2.54	2.90	3.19	3.49	3.78

Bootstrapped standard errors in parentheses. * significant at 5% level.
Controls for student's and roommate's academic background (high school GPA and admissions test scores), student's and roommate's parental background (father's education, mother's education, parental income), type of admission tests, and dummy variables for cell included in all regressions.

Table 8 - Peer Effect Dynamics. Males from '97 Lottery Sample Cohort

	Outcome	
	1998 GPA [1st year]	1999 GPA [2nd year]
Roommates' high school drinking		
Frequent	-0.183	-0.428*
	(0.117)	(0.181)
Occasional	-0.151	-0.297*
	(0.102)	(0.143)
Student's high school drinking		
Frequent	-0.137	-0.250
	(0.145)	(0.193)
Occasional	0.021	-0.043
	(0.103)	(0.133)
Observations	342	332
R^2	.538	.507
Adjusted R^2	.171	.109

Robust standard errors in parentheses. * significant at 5% level.

Huber-White standard errors were calculated using roommate clusters.

Controls for student's and roommate's academic background (high school GPA and admissions test scores), student's and roommate's parental background (father's education, mother's education, parental income), type of admission tests, and dummy variables for cell included in all regressions.

Table 9 - Effect of Roommates' High School Drinking on Cumulative GPA at the End of Summer 1999, by Own High School Drinking. Males from Lottery Sample.

		Sub-sample of males		
	Males only	Did not drink in high school	Drank occasionally in high school	Drank frequently in high school
Roommates' high school drinking				
Frequent	-0.282*	-0.273	-0.119	-0.992
	(0.128)	(0.348)	(0.178)	(0.517)
Occasional	-0.263*	-0.447*	-0.279	-0.487
	(0.101)	(0.199)	(0.167)	(0.428)
Student's high school drinking				
Frequent	-0.109	-	-	-
	(0.150)	-	-	-
Occasional	-0.028	-	-	-
	(0.119)	-	-	-
Observations	456	147	232	75
R^2	0.595	0.883	0.603	0.899
Adjusted R^2	0.173	0.536	-0.042	0.320

Robust standard errors in parentheses. * significant at 5% level.
Huber-White standard errors were calculated using roommate clusters.
Controls for student's and roommate's academic background (high school GPA and admissions test scores), student's and roommate's parental background (father's education, mother's education, parental income), type of admission tests, and dummy variables for cell included in all regressions.

Table 10 – Frequency of Alcohol Drinking during College
For males, by roommate pre-college drinking*

	Roommate pre-college drinking		
	Drank frequently in high school	Drank occasionally in high school	Did not drink in high school
Drank alcohol in past 12 months			
Never	0%	2%	2%
Once a week or less	42%	54%	59%
2-4 times a week	55%	37%	34%
Almost every day	4%	6%	5%
Involved in binge drinking			
Ever*	94%	90%	81%
In past 12 months**			
Never	2%	5%	10%
Once a week or less	52%	65%	69%
2-4 times a week	42%	27%	21%
Almost every day	4%	2%	0%
In past 2 weeks**			
None	19%	28%	37%
Once	19%	17%	20%
Twice	21%	18%	9%
3-5 times	30%	27%	26%
6 or more times	11%	10%	7%
Observations	53	155	87

* Based on a survey administered in the winter of 2002 to a sample of students who entered the university in 1998-2000 and who were randomly assigned to their first year roommate(s).

** Only asked to students who had ever been involved in binge drinking.

Binge drinking is defined as the consumption of at least five drinks in a row for men or four drinks in a row for women.

Number of Observations reported is based on first two items ("Drank alcohol in past 12 months" and "Involved in binge drinking ever"). Number of observations for bottom two items were generally lower due to the fact that the associated questions were asked only to those who reported binge drinking ever, and also due to item non-response (which was never greater than 15%).

Table 11 – Possible Mechanisms behind Effects of Roommate Drinking

Hypothesis	What we should observe	Do we observe it?
Disruption:	Effect fades over time	No
Roommates who drink disrupt study	No larger effect for frequent drinkers	No
	Larger effect for students with high GPAs	No
Peer influences in preferences and addiction:	Effect persists over time	Yes
	Larger effect for frequent drinkers	Yes
Students develop strong preferences for, or get addicted to, alcohol	Students with roommates who drank prior to college are more likely to drink in college	Yes

Table 12- Effect of Substance-Free Residence Hall on Student's GPA (OLS Estimates).
Lottery Sample

	Males only				Females only			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Substance-free residence hall	0.077	0.073	.001	-0.005	-.129*	-.113	-.103	-.200*
	(0.070)	(0.072)	(.073)	(0.087)	(.058)	(.059)	(.061)	(.087)
Roommate's high school drinking								
Frequent			-.252*	-0.253*			.038	-.019
			(.067)	(0.073)			(.060)	(.067)
Occasional			-.263*	-0.278*			.032	-.033
			(.061)	(0.065)			(.055)	(.059)
Interactions								
Substance free * Frequent				-0.035				.153
drinking roommate				(0.156)				(.128)
Substance free * Occasional				0.038				.165
drinking roommate				(0.127)				(.124)
Student's high school drinking								
Frequent		-0.093	-.072	-0.072		.011	.006	.009
		(0.095)	(.092)	(0.092)		(.060)	(.060)	(.061)
Occasional		0.074	.106	0.106		.067	.064	.066
		(0.069)	(.067)	(0.067)		(.052)	(.052)	(.055)
Observations	457	457	456	456	556	556	555	555
Adjusted R-squared	0.087	0.093	0.122	0.121	0.144	0.145	0.141	0.142

Robust standard errors in parentheses; * significant at 5%.
Huber-White standard errors were calculated using roommate clusters. Controls for student's and roommate's academic background (high school GPA and admissions test scores), student's and roommate's parental background (father's education, mother's education, parental income), type of admission tests, and dummy variables for cell included in all regressions.