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College Achievement and Earnings

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College Achievement and Earnings

Jonathan Gemus*

January 4, 2010

Abstract

I study the size and sources of the monetary return to college achievement as measured by cumulative Grade Point Average (GPA). I first present evidence that the return to achievement is large and statistically significant. I find, however, that this masks variation in the return across different groups of people. In particular, there is no relationship between GPA and earnings for graduate degree holders but a large and positive relationship for people without a graduate degree. To reconcile these results, I develop a model where students of differing and initially uncertain ability levels choose effort level in college and whether to earn a graduate degree. College achievement and graduate attainment are allowed to increase human capital and be used by employers to screen workers. In the separating equilibrium studied, workers who earn a graduate degree can effectively signal high productivity to employers. As a result, employers use undergraduate GPA—a noisy signal of productivity—to screen only the workers who do not hold a graduate degree. Viewing the empirical results through the lens of this equilibrium, the zero GPA-earnings relationship for graduate degree holders and the positive and large relationship for people without a graduate degree suggests that most of the return to achievement net of graduate educational attainment is driven by sorting.

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1 Introduction

Talk to almost any college student on any campus, and there is a good chance that he or she will be at least somewhat concerned about performance in school. In a recent survey of undergraduates conducted by the Higher Education Research Institute (HERI (2007)), 64.9% of college freshman reported that they spent at least 6 hours per week outside of the classroom studying or doing homework.¹ Additionally, the typical student spent at least 11 hours per week in the classroom or lab (HERI (2007)), and the going rate for an hour of tutoring from economics graduate students at one private, Midwestern university is \$50 per hour—more than twice the hourly wage of research assistants at the same school.

Students incur these costs in the hope of future returns: success in school is widely viewed by both policy makers and researchers as vital to the material well-being of individuals later in life. Accordingly, many education policies are aimed at raising student achievement. To the extent that private decisions and public policies to raise achievement are costly, it is of interest to determine the return to achievement in college.

As is discussed in more detail below, several earlier papers have examined the relationship between college GPA and earnings and have generally found the relationship to be positive and reasonably large.² In this paper, I attempt to add to this literature in two ways. First, more recent data is used to update and extend the existing evidence about about college achievement and it's relationship to earnings. Second and more importantly, I examine the extent to which graduate attainment, human capital, and signaling drive the GPA-earnings relationship.

Using the 1993 cohort of Baccalaureate and Beyond, I find that the relationship between GPA and earnings is large, positive, and statistically significant ten years after graduating college. Conditional on graduating college, GPA is negatively correlated with being male, college quality and, surprisingly, parent income and education. These characteristics tend to be positively correlated with earnings, so after controlling for a number of background characteristics that are widely considered to be predictors of both achievement and of earnings, the relationship between

¹While this may not sound like a tremendous amount of work, only 44.9% of high school seniors reported similar amounts of work.

²See Weisbrod and Karpoff (1968), Wise (1975), Jones and Jackson (1990), and Loury and Garman (1995).

GPA and earnings becomes larger. Based on this result, I argue that under the assumption that selection on unobservable variables has the same sign as selection on observable variables, the estimates from these regressions reflect a lower bound on the “true return” to college achievement (Altonji, Elder and Taber (2005)). While this does not offer a point estimate of the return to achievement, it is a weaker assumption than the “no selection on unobservables” assumption that has been employed so far in this literature.

In attempting to better understand the relationship between college achievement and earnings, I first investigate whether the GPA-earnings relationship is driven by graduate school attainment. Several pieces of evidence that support this hypothesis. Most importantly, students with higher GPAs are more likely to earn graduate degrees, and the return to graduate education is quite substantial. Furthermore, most students work between college and graduate school (so most graduate degree holders have earnings observations before and after graduate school), and there is a positive relationship between GPA and earnings growth.³

However, the hypothesis that graduate school completely explains the GPA-earnings relationship is ultimately rejected. While there is little relationship between GPA and earnings net of highest degree in the entire sample, this result masks heterogeneity by graduate attainment. Specifically, I find that there is actually a positive, significant, and fairly large GPA-earnings relationship for those without a graduate degree. This is not consistent with a graduate degree-driven GPA-earnings relationship. In contrast, the relationship between GPA and earnings among those with a graduate degree is close to and statistically no different from zero.

In order to reconcile these results, I develop a model in which college achievement and graduate school can both increase productivity and signal ability to employers. The separating equilibrium studied describes the key idea that ability is at least partially revealed to the labor market by a student’s post-college educational decisions, and this dilutes the importance of GPA—a noisy signal of ability—as a screen for those workers who signal high ability by attaining a graduate degree. However, GPA is still used to screen workers with no graduate degree and can potentially

³I am not the first to document most of these empirical relationships: see for example Mullen, Goyette, and Soares (2003) for the relationship between college GPA and graduate attainment, Arcidiacono, Cooley, and Hussey (2008) for evidence on the return to earning an MBA, and Wise (1975) for the relationship between GPA and earnings growth.

increase the productivity of all college graduates regardless of ultimate educational attainment. Thus the GPA-earnings relationship for graduate degree holders primarily reflects the productive effect of college achievement, while the relationship for those with no graduate degree reflects both a productive and signaling effect of achievement. Roughly speaking, the difference between these two relationships reflects the signaling effect of college achievement.

Recalling that the GPA-earnings relationship for respondents with a graduate degree is close to and not statistically different from zero while the relationship is large, positive and significant for respondents with only a bachelor's degree, this equilibrium suggests that most of the return to achievement net of highest degree is due to sorting, not human capital.

2 Literature Review

Compared to the large body of research that examines the returns to quantity of education and the growing, more recent literature on the returns to attending a more selective college, relatively few papers in economics study the return to college achievement. Weisbrod and Karpoff (1968) examine the relationship between class rank and earnings, while Wise (1975) and Jones and Jackson (1990) study the effect of college achievement as measured by GPA on earnings growth. Loury and Garman (1995) estimate the relationship between GPA and earnings as well; however, they focus their paper more on the relationship between college selectivity, race and achievement than on estimating and interpreting the returns to GPA.

Two points consistently emerge from these studies. First, all authors find a positive and significant relationship between GPA and earning levels and growth and argue that the estimate is causal. Using data from a single firm's internal records, Wise (1975) finds that employees with a higher GPA see higher earnings growth and argues that this relationship is causal.⁴ Jones and Jackson (1990) use administrative and survey data from a single university to estimate the return to college GPA one year and five years after college. They too find a positive and significant

⁴However, a causal interpretation of these results is complicated by the inclusion of endogenous control variables such as class rank in graduate school. I discuss this issue more below. See also Griliches and Mason (1972), Griliches (1977), and Chamberlain (1977).

relationship between GPA and earnings. Using the National Longitudinal Survey Class of 1972, Loury and Garman (1995) also find a positive relationship between GPA and earnings.

The second point that emerges from this literature is that the return to college achievement is due primarily to its positive effect on productivity rather than its use to screen workers. Wise (1975) argues that several patterns in his data support this claim. For example, he finds that there is no relationship between GPA and initial salary or initial position with the firm he studies but that there is a relationship between GPA and earnings after spending time at the firm. He argues that this is not consistent with screening but that it is consistent with GPA increasing productive capacity. However, as Lazear (1977) points out, one interpretation of this result is that firms sort workers into jobs by their expected ability to acquire job related skills, and GPA is used as an indicator of a worker's expected ability. Similarly, Jones and Jackson (1990) argue that their evidence supports the hypothesis that college achievement increases human capital, but this evidence runs into the same problem as Wise (1975): it can be argued that their evidence supports the screening hypothesis as well.⁵

Distinguishing between human capital and sorting explanations of the returns to education is notoriously difficult because, from workers' and firms' perspectives, educational investment and hiring decisions are independent of whether education increases or signals productivity—workers only care how much education increases earnings, and firms only care that they maximize profits. In order to disentangle the human capital and sorting hypotheses, some economists have argued that educational screening is more necessary for some workers than others (Wolpin (1977), Riley (1979)). These differences can translate into differences in investments in education and lifetime earnings among workers for which screening is more or less important. Others have argued that variation in educational constraints has different implications for pure human capital models

⁵The first piece of evidence cited by Jones and Jackson is that there is a positive relationship between GPA and earnings just after college. The second piece of evidence is that women working at large establishments see a higher return to GPA than their peers at smaller establishments, while the third piece of evidence cited relates to the returns to tenure in occupations that should be more likely to provide training versus occupations that should be less likely to provide training. In all three cases, one can come up with plausible stories in which either a screening or human capital argument is plausible. For example, a positive relationship between GPA and initial earnings could reflect the fact that students with higher GPAs are more productive, or it could reflect that employers don't observe true productivity when initial wages are set, so wages are set according to observables such as GPA that are potentially correlated with productivity.

and screening models of education (Lang and Kropp (1986), Bedard (2001)). The approach in this paper differs from these earlier works in the sense that this paper proposes a human capital and signaling model to reconcile a set of empirical results. The papers by Wolpin (1977), Riley (1979), Lang and Kropp (1986) and Bedard (2001) propose models that make predictions which are then brought to data.

3 Data

The data used in this paper come from Baccalaureate and Beyond 93/03 (B&B), a longitudinal study of individuals expecting to graduate from 4-year bachelor degree programs in the 1992/1993 school year. The data were collected by the National Center for Education Statistics (NCES) in the U.S. Department of Education. The sample was created from a subsample of respondents to the National Postsecondary Student Aid Study (NPSAS), and data from NPSAS serves as the base year data for B&B. This provides a national picture of college graduates, and the sampling was done in order to provide an “optimum sample of graduating seniors in all majors” (Griffith (2008)). The base year data provide information about college admission test scores, the institution from which respondents graduated, and demographic and family background variables.

Following the base year of the study, 11,192 graduates were chosen to be surveyed three times in their first ten years after college—one year after college in 1994, four years after in 1997, and ten years after in 2003. Respondents were questioned about several aspects of their post-college lives, but I focus on the information about labor market experiences and further educational attainment. The data provide information regarding the highest degree a respondent possessed at the time of the survey, (annual) earnings in each survey year, and years of labor market experience accumulated after college.^{6,7}

⁶I focus on annual earnings because my sample consists of college graduates working full time. The hours worked for this group is quite high: the 25th percentile of the hours worked distribution is 40 hours, and half of the respondents in the sample report working more than 40 hours per week. Also, approximately 82% of B&B respondents who report rate of pay in 2003 report annual earnings.

⁷There is no information specifically about pre-college labor market experience, but there is information about age, so to the extent that this variable can serve as a proxy for pre-college experience, problems arising from the omission of labor market experience are mitigated.

In addition to the base year and follow-up surveys, B&B also conducted a transcript study. This involved requesting and collecting transcripts from respondents' colleges, and it provides data on achievement in the form of cumulative GPA as well as information regarding major field of study and college attended.⁸ While most colleges use a four point grading scale (in which an A=4, B=3, C=2, D=1, and F=0), a number of schools, while also using a four point scale, award +'s and -'s (e.g. students can earn a B+, B, or B-), and a few even grade on a 100 point scale. In order to place grades on a common scale, B&B converted everything into a four point scale with no +'s or -'s.

Finally, I merge B&B with the U.S. News and World Report College Rankings from the 1992/93 school year. These rankings are used as a measure of college quality.⁹ In its 1992/93 edition, the U.S. News College Rankings divided colleges into research universities and liberal arts colleges and then separately divided these two categories of colleges into five different tiers, first being the most selective schools and fifth being the least selective schools. Since U.S. News did not rank every college in the country, a sixth tier is added that includes all colleges not ranked by U.S. News. I do not distinguish between liberal arts and research universities, so college quality is measured by dividing all universities into six tiers. More details about the variables used in the analysis and how the sample was created can be found in the data appendix.

Table 1 displays sample statistics. With the mean GPA being 3.03, the average college graduate is a solid "B" student. Recalling that the first five tiers of colleges are ranked by U.S. News and the sixth tier includes all colleges not ranked, Rows (2) through (7) show that nearly one-half of the students graduated from schools not ranked by U.S. News with most of the remaining students concentrated in third and fourth tier schools. Only 7% and 9% of students attended first and second tier schools, respectively. Half of respondents had a father with at least a college degree, and nearly 40% had mothers with at least a college degree. This is in sharp

⁸GPA is typically an average of course grades weighted by the number of credits the course is worth. Cumulative GPA is this weighted average at the time of graduation.

⁹U.S. News College Rankings are can be somewhat controversial as a measure of college quality. Despite this, they are one of the best known and most widely available ranking guides, so it is likely that this is a measure of college quality that employers can easily observe and price into wages. Due to the imperfect nature of any ranking system and the fact that GPA is a within school measure of achievement, I also run regressions with college fixed effects instead of U.S. News rankings. The results are robust to using either measure of college quality.

contrast to the general population of adults in their 50s—approximately 23% of this group has earned a college degree. Respondents’ parents similarly earn far more money than the general population: over \$54,000 for the former and about \$23,000 for the latter. By ten years after graduation, most students had not earned a higher degree, but 21% earned a master’s degree, 5% earned a professional degree, and only 2% earned a doctoral degree.¹⁰ 67% of respondents earning a graduate degree studied a field that is closely related to a profession (engineering, education, business, medicine, law, etc), while only 22% earned a degree in arts and humanities, social and behavioral sciences, or life and physical sciences. Thus most graduate education is undertaken in a field that is closely related to a profession.

54% of respondents are female, and the vast majority of respondents are white. Unfortunately, there are so few non-white respondents that it is not possible to run meaningful regressions after breaking down race/ethnicity more than a simple white/non-white dichotomy. However, I do present a complete breakdown of race/ethnicity in Table 1, and the regression results are unchanged when the race/ethnicity breakdown is defined so that Asian respondents are included with white respondents instead of non-white respondents.

Finally, as of 2003, 10% of respondents work as educators, and 30% work in business and management. 11% work in medicine while human/protective/legal professions claim 10% of respondents. 10% of respondents also work in the service industry, and the occupations of the remainder of the sample are divided into engineering, computer science, editors/writers/performers, research, administrators, mechanics/laborers, and other/military.

¹⁰Of the people who reported earning a master’s degree, approximately 13% studied education and 20% studied business (“Business” includes earning an MBA as well as degrees such as a master’s in finance). The remainder were divided between arts, humanities, social and physical sciences, engineering, and medicine/health. Respondents who earned a professional degree were essentially divided between law and medicine: approximately 29% earned a medical degree and 65% earned a law degree. The majority of people earning a doctorate were in social and physical sciences and engineering, though there were a number of individuals earning degrees in arts, humanities, education, business and medicine. There were also a handful of people who reported earning a doctorate in law.

4 The Relationship between GPA and Earnings

I begin by estimating the following equation:

$$w_i = \alpha G_i + X_i \beta' + f(EXP_i) + \epsilon_i, \quad (1)$$

where w_i is log annual earnings for person i 10 years after graduating college, G_i is college GPA, X_i is a vector of background variables, EXP_i is labor market experience 10 years after college, and ϵ_i is an error term. $f(\cdot)$ is approximated by a quadratic polynomial. X_i , the vector of background variables, includes a measure of school quality (either the U.S. News ranking or a school fixed effect), major field of study dummies, SAT/ACT scores, age at graduation, gender, race/ethnicity, and parents' income and education.

Table 2 presents results from the estimation of four specifications of Equation (1) using log earnings ten years after graduating college as the dependent variable.¹¹ Column (1) presents results from a regression of log earnings on GPA and a quadratic polynomial in labor market experience. The estimate of the coefficient on GPA is both quantitatively large and statistically significant: a one point increase in GPA is associated with a 7.9% increase in earnings. Column (2) adds controls for school rank and major field of study.¹² The estimated coefficient on GPA rises from 7.9% to 8.3% so that a one point increase in GPA is associated with an 8.3% increase in earnings. Column (3) adds the remaining control variables (parents' income and education, race, gender, and SAT/ACT scores). Far from reducing the estimated coefficient, the inclusion of these control variables further raises the estimate so that a one point increase in GPA is associated with a 9% increase in earnings.

To the extent that GPA is a measure of achievement that is defined within rather than across schools, the relationship between GPA and earnings should be estimated from variation

¹¹Unless otherwise noted, all regressions are estimated using earnings and labor market experience 10 years after graduating college (in 2003). 2003 sample weights are used, though the results change very little when no weights are used. All standard errors are clustered by the college the respondent graduated from. See the Data Appendix for more details.

¹²First tier schools and Business/Management are the excluded categories for school rank and major field dummies, respectively.

within schools. Column (4) therefore estimates a regression of log earnings on GPA, all other independent variables (besides school rank), and a school fixed effect. At 9.4%, the estimated relationship between GPA and earnings is even larger and significantly different from zero.

In addition to the estimated return to college achievement I include the estimated coefficients from a number of variables in the regressions. I will focus on Column (3) of Table 2. Students attending first tier colleges earn between 11.5% and 18.3% more than their peers at fourth, fifth and sixth tier colleges, though earnings differences between students attending first and second and first and third tier schools are far smaller (about 0.5% and 5.7%, respectively) and statistically no different from zero. The coefficient on SAT/ACT test scores is insignificant and very small, while parent's income is positively associated with earnings – a \$50,000 increase family income is associated with a 2% to 3% increase in earnings. Men earn approximately 28.1% more than women, but the white/non-white wage differential is small and insignificant. Finally, the coefficients on mother's and father's education are generally small and not significantly different from zero.

Thus there is a large, positive and significant relationship between GPA and earnings, and this result is quite robust to the inclusion of several variables that are often considered very important in determining both achievement as well as earnings – if anything, the GPA-earnings relationship slightly increases as more covariates are added to the regressions.

One way to think about this result is in terms of omitted variables. The first column of Table 2 displays results from a regression that does not include X_i ; the final three columns display results from regressions that do include X_i . The difference in these estimates is due to omitted observable variables in the first column, and omitting X_i leads OLS regressions to underestimate the relationship between GPA and earnings. If omitting unobservable variables has a similar effect, one can think of the estimates in Columns (3) and (4) as lower bounds on the true return to GPA (Altonji, Elder, and Taber 2005).

The implication of this result is that the correlation between G and X has a different sign than the correlation between earnings and X . In results that are not shown here but are extensively documented elsewhere, the variables that constitute X , such as parents' education and income,

are positively related to earnings.¹³ However, many of these variables are negatively associated with college GPA.¹⁴ Table 3 presents results from regressions of GPA on various definitions of X . One thing that comes across regardless of which regressors are used is that measures of a more advantaged upbringing are *negatively* correlated with GPA. Those respondents with parents above the bottom income quartile earn GPAs that are anywhere from about 0.048 to 0.061 points lower than their peers with parents in the bottom quartile of the income distribution. While this relationship is not very large—0.05 points is approximately one tenth of a standard deviation for GPA—it is still negative and significantly different from zero. Column (5) of Table 3 replaces family income quartile with actual family income and similarly finds that a \$50,000 increase in family income is associated with a 0.017 point drop in GPA. Column (6) replaces U.S. News rankings with school fixed effects. This reduces the coefficient on family income by close to half. While it is no longer significant at conventional levels and quite small, the correlation is still negative.

Other characteristics that are positively correlated with income also tend to have a negative or zero correlation with GPA. Respondents with parents with at least some college earn slightly lower GPAs than those with parents who have no more than a high school diploma, though these differences generally are not statistically significant. In contrast, respondents coming from fourth through sixth tier schools typically earn GPAs that are anywhere from 0.10 to 0.12 points higher than students at first tier schools. Finally, men earn GPAs that are on average between 0.136 and 0.162 points lower than those earned by women. Since there is generally a positive relationship between family income, being male, school rank, and parents' education on the one hand and

¹³Similarly, white respondents earn more than non-white respondents; men earn more than women, etc. See Altonji and Blank (1999) and Solon (1999) for reviews.

¹⁴It is important emphasize here that this sample is limited to college graduates. Therefore these results suggest that G and X are negatively correlated conditional on graduating college. Using this data set, nothing can be said about the correlation of G and X conditional on college attendance let alone the unconditional correlation. An attempt is made to better understand these results in Gemus (2009). While earlier research has found little evidence of borrowing constraints (Carneiro and Heckman (2002) and Cameron and Taber (2004), though Belley and Lochner (2007) have found that more recent cohorts are more constrained), one important difference between richer and poorer college students is that less well off students are far more likely to pay for their own college education (whereas wealthier students' families are more likely to pay for college). From the point of view of the student, this leads to large differences in the average price of college for richer and poorer students, and this can affect selection into college. Gemus (2009) finds that the cognitive test scores of college graduates who pay for their own education are between one quarter and one half of a standard deviation above the scores of their peers who do not pay for their own college education.

earnings on the other, regressions that omit X find smaller estimates than regressions that do not.

One question that this analysis raises is whether the estimated relationship between GPA and earnings can be interpreted as causal. That is, does OLS estimate the true return to achievement? I have shown that omitting a number of observable variables does little to change the estimated return to achievement; however, omitting unobservable variables may have an effect that is a different sign and/or magnitude. In particular, there may be variables that employers observe and care about that researchers do not observe.

While this possibility is ultimately untestable, the assertion that the estimated return to achievement is positive and close to the true return may be plausible for two reasons. First, the regressions condition on school rank (or a school dummy variable) and college admission test scores. Including college dummy variables serves as a proxy for many things that employers observe but researchers do not observe. Admission to college often requires a personal essay, letters of reference, test scores, a high school transcript, and sometimes even an interview. To the extent that this information is highly correlated with the information employers receive from a CV and an interview, college quality serves as a proxy for many of these variables. Similarly, achievement test scores are determined by some combination of non-cognitive and cognitive skills that may be relevant to work, and SAT/ACT scores serve as a proxy for these skills.

Second, as discussed above, adding X to regressions does little to change the estimated coefficient on GPA and if anything slightly increases it. If adding unobservable variables to these regressions has a similar effect, then the true return to achievement is at worst larger than and at best close to the estimated coefficient (Altonji, Elder and Taber (2005)).¹⁵

¹⁵In the words of Altonji et al., the true return to GPA would be close to and slightly larger than the estimates presented in Table 2 under the assumption that selection on unobservable variables has the same sign and similar magnitude to selection on observable variables.

5 Understanding the GPA-Earnings Relationship

One potential issue in interpreting these estimates is whether they should be thought of as a direct or indirect relationship between GPA and earnings. That is, assuming for the moment that there is a causal relationship between GPA and earnings, does GPA directly raise earnings? Or does GPA raise the probability of earning a graduate degree which in turn raises earnings? The second explanation is plausible for four reasons: (1) GPA is positively associated with graduate degree attainment, (2) graduate degree holders tend to earn more than bachelor degree holders, (3) most graduate degree holders work between college and graduate school – of the respondents with a graduate degree, only 19% were enrolled in a graduate program one year after college graduation while 79% had a full-time wage observation at the same point in time – and (4) GPA is positively associated with earnings growth. Others have documented these relationships before, though not with B&B (see Mullen, Goyette, and Soares (2003), Arcidiacono, Cooley, and Hussey (2008), and Wise (1975)). I therefore relegate discussion of (1) and (4) to Appendix ?? using data from B&B. As will be seen, the second point is more central to this analysis so I present evidence on it momentarily.

Taken together, these empirical relationships suggest the possibility that the GPA-earnings relationship is largely driven by the positive association between GPA and graduate attainment on the one hand and graduate attainment and earnings on the other. If the return to earning higher grades in college is driven by graduate attainment, then net of highest degree earned one would expect that GPA is not as important in determining wages.

One must be careful in testing such a hypothesis, however. Consider estimating an equation such as

$$w_{it} = \alpha G_i + X_i' \beta + HD_{it}' \delta + f(EXP_{it}) + \epsilon_{it}, \quad (2)$$

where HD_{it} is a vector of highest degree dummies for person i at time t . HD_{it} is a “bad control” in this regression (Griliches and Mason (1972), Griliches (1977), Chamberlain (1977), Angrist and Krueger (1999), Angrist and Pischke (2008)): highest degree is likely causally related to college grades, and unobserved determinants of highest degree are probably correlated with unobserved

determinants of wages. In this case, even if G_i is uncorrelated with ϵ_{it} , estimates of α will be biased.¹⁶

In order to deal with this issue, it is necessary to obtain a consistent estimate of δ . I do this by employing a two-stage procedure where the first stage is

$$w_{it} = HD'_{it}\delta + f(EXP_{it}) + \gamma_i + \tilde{\epsilon}_{it}, \quad (3)$$

where γ_i is an individual fixed effect. As was mentioned above, since most graduate degree holders work between college and graduate school, most have earnings observations before and after graduate school. It is therefore possible to difference out constant unobservable characteristics. So long as HD is only correlated with γ_i and not $\tilde{\epsilon}_{it}$, Equation 3 will consistently estimate δ .¹⁷

Using the estimates of δ and $f(\cdot)$, $\hat{\delta}$ and $\widehat{f(\cdot)}$, to adjust earnings, in the second stage the regression

$$\hat{w}_{it} = \alpha G_i + X'_i\beta + \epsilon_{it} \quad (4)$$

is estimated, where $\hat{w}_{it} = w_{it} - HD'_{it}\hat{\delta} - \widehat{f(EXP_{it})}$ and $t = 10$ years after college.¹⁸

Results from the first stage regression are presented in Table 4. Column (1) presents estimates of a regression of log earnings on highest degree dummies, labor market experience, and experience squared. Net of labor market experience, respondents with master's, professional, and doctoral degrees earn on average 32%, 58.2%, and 57.5% more than respondents with bachelor's degrees, respectively. Column (2) adds in school rank, major, and background controls, and Column (3)

¹⁶To see this, suppose that

$$\begin{aligned} w &= r_1G + r_2HD + u_1 \\ HD &= r_3G + u_2 \end{aligned}$$

where HD is a scalar, G is uncorrelated with u_1 and u_2 but u_1 and u_2 are correlated with each other. Then the estimate of r_2 does not converge in probability to r_2 . The estimate of r_1 is $\hat{r}_1 \xrightarrow{p} r_1 - r_3q$, where q is the coefficient from a regression of u_1 on u_2 . See Griliches and Mason (1972), Griliches (1977), Chamberlain (1977), Angrist and Krueger (1999) and Angrist and Pischke (2008) for details.

¹⁷Specifications that include year dummies produce identical results. These regressions account not only for constant unobserved heterogeneity but also time varying unobservables that are common to all college graduates (e.g. annual labor market fluctuations).

¹⁸Note that the first stage makes use of data from all three follow-up surveys (1 year, 4 years, and 10 years after college) while the second stage only makes use of data from the final follow-up survey 10 years after college.

includes a person fixed effect. Moving from the first to second column, the coefficients on the different degrees all decrease, so that relative to students whose highest degree is a bachelor's, students with master's degrees earn 7.6% more, professional degree holders earn 39.3% more, and doctoral degree holders earn 25.3% more. Thus students appear to positively select on observable characteristics into graduate school. Interestingly, selection on unobservable, constant heterogeneity appears to be *negative*: after adding the individual fixed effect, estimates indicate that relative to bachelor's degree holders master's degree holders earn 23.7% more, professional degree holders earn 62.6% more, and doctoral degree holders earn 69.2% more. These estimates are quite close to those from the OLS regression with no controls. Thus it appears that negative selection on constant, unobservable variables offsets selection on constant, observable variables. This result is consistent with earlier research by Angrist and Newey (1991) and Arcidiacono, Cooley, and Hussey (2008), where fixed effect estimates of the return to schooling are larger than OLS estimates.¹⁹

Table 5 presents estimates of the GPA-earnings relationship net of highest degree. Column (1) displays results from an OLS regression of 2003 log earnings on GPA, school rank, major field of study, labor market experience, labor market experience squared, and highest degree dummies. At 0.059, the GPA-earnings relationship is positive, significant, and fairly substantial net of highest degree. However, these results do not account for the possibility that highest degree is a “bad control”.

Columns (2) through (4) of Table 5 display results from the second stage of the two stage procedure outlined above. Column (3) presents results from the second stage when the full set of controls is included. Net of highest degree, there appears to be little relationship between GPA and earnings, though the standard errors here are quite large (the 95% confidence interval is [-0.037, 0.052]). When college fixed effects are used instead of college rank dummies, the results

¹⁹Arcidiacono, Cooley, and Hussey (2008) is most closely related to this result as they are specifically looking at the return to earning an MBA. They find negative selection into MBA programs along unobservable variables: fixed effect estimates of the return to earning an MBA are larger than OLS estimates. When they break the estimates up by program rank, however, they find that students positively select into top programs and negatively select into lower ranked programs. Regarding the negative selection into lower ranked programs, they argue that one possibility is that “softer” skills such as social skills are rewarded labor markets. People with lower levels of these softer skills and higher levels of academic skills find it most beneficial to earn an MBA.

are similar: the relationship between GPA and earnings is close to zero and not statistically significant, but the confidence interval is large at $[-0.041, 0.059]$. In both specifications, the upper bounds of the confidence intervals around the GPA-earnings relationship overlap with the confidence intervals of the corresponding estimates in Columns (3) and (4) of Table 2.

At first glance this table appears to tentatively support the hypothesis that graduate education explains much of the GPA-earnings relationship, but this story does not hold up very well after a closer look at the data. If graduate attainment explains the GPA-earnings relationship, then one would expect there to be little relationship between GPA and earnings for people whose highest degree is a bachelor's degree. The data does not support this, however – in fact, the data indicate that there is a substantial relationship between GPA and earnings for respondents whose highest degree is a bachelor's and almost no relationship for graduate degree holders.

I once again consider the two-stage procedure outlined above but change the second stage to

$$\tilde{w}_{it} = \alpha_1 G_i + \alpha_2 G_i(1 - S_{it}) + X_i \beta' + \nu_{it}, \quad (5)$$

where $S_{it} = 1$ if the respondent has earned a graduate degree and $t = 10$ years after college.²⁰ One can interpret α_1 as the GPA-earnings relationship for graduate degree holders and $\alpha_1 + \alpha_2$ as the relationship for people who do not have a graduate degree.

Table 6 presents results from this second stage. Column (1) presents results from a regression of adjusted log earnings on GPA and its interaction with $1 - S$ controlling for school rank and major field of study. The estimate of α_1 is negative but not statistically different from zero. In contrast, the estimate of α_2 is 0.053 and statistically significant at the 1% level. Column (2) presents results with all variables in X (parents' income and education, race, gender, age at graduation, test score) included in the regression. The estimate of α_1 is almost exactly zero while, at 0.058, the estimate of α_2 is once again positive and statistically significant. The estimate of the GPA-earnings relationship for bachelor degree holders ($\alpha_1 + \alpha_2$) is 0.051 and is significant at the 5% level (the standard error is 0.025).

²⁰Once again, the first stage uses data from all three follow-up surveys while the second stage makes use of data from the final follow-up 10 years after college.

Columns (1) and (2) of Table 6 both find that the GPA-earnings relationship is positive, large and significant for those without a graduate degree while the relationship for graduate degree holders is close to and not statistically different from zero. The estimates of these coefficients are quantitatively quite different from each other, and they are also statistically different in the sense that their 95% confidence intervals do not overlap. In Column (3) I include school fixed effects in the regression. The estimate of α_1 , -0.01, is once again small and insignificant, and the estimate of α_2 , 0.065, is large and significant at the 1% level. The relationship for bachelor degree holders ($\alpha_1 + \alpha_2$) is 0.055 and is significant at the 5% level (the standard error is 0.023).

This evidence is not consistent with the story that the GPA-earnings relationship is driven by graduate degree attainment. I consider a human capital and signalling model below that reconciles these results.

6 A Human Capital and Signaling Model of College Achievement

The results from the previous section indicate that the relationship between GPA and earnings is positive and large. Graduate education does not appear to be the main pathway through which achievement increases earnings, since the GPA-earnings relationship is large and positive for respondents without a graduate degree and close to zero for graduate degree holders. In this section I leave aside the question of whether the results presented above are causal and assume they are. I use the model to argue that the empirical results presented above shed light on the extent to which the return to college achievement is driven by signaling and the extent to which the return is driven by the effect achievement may have on productivity.

The human capital versus sorting question is an open one in the literature on the return to college achievement. This question is important to the extent that we care about the social returns to achievement. If the return to achievement comes from sorting rather than increasing human capital, the social return is informational, and this has policy implications. For example, the benefits from a policy of tying financial aid to GPA are much different if GPA increases

human capital than if it is used to sort workers. In the former case, this policy could raise the economy-wide stock of human capital, while in the latter case, the social returns could be zero if the ordinal ranking of students by GPA is identical with and without this policy.

In the model, students of differing and initially uncertain abilities choose effort level in college and whether to attend graduate school. Ability affects productivity, and college achievement and graduate school are allowed to both increase productivity and signal ability to employers. Students are uncertain about their innate productivity prior to the effort decision, so even in a separating equilibrium some low productivity types have a high GPA and some high productivity types have a low GPA. Students learn their ability while attending college, and in the separating equilibrium I study they are able to effectively signal high ability to the labor market by earning a graduate degree. Students choosing to forgo graduate school may have higher or lower innate productivity, so GPA is still informative about the productivity of students with no graduate degree. Thus achievement is used to screen only the workers who choose not to earn a graduate degree. The implication of this equilibrium is that college achievement affects earnings only by augmenting human capital for workers with a graduate degree while it affects earnings through both human capital and screening for workers without a graduate degree.

The model has three periods, and people can have one of three different ability levels: η_h , η_m , and η_l , where $\eta_h > \eta_m > \eta_l$. η is a measure of ability or productivity that cannot be directly observed by employers. There are large numbers of each type of worker, there is no discounting across periods, and workers are risk-neutral. At the start of the model neither employers nor agents know their types. Instead, people have beliefs about their own ability that are determined by an informative signal, and the distribution of types is common knowledge across agents and firms. This distribution is given by $0 < Pr(\eta = \eta_j) = \rho_j < 1$ such that $\sum_j \rho_j = 1$ for $j = h, m, l$. The beliefs, $b = \{h, m, l\}$, are private knowledge and informative so that $\theta_j^k = Pr(\eta = \eta_j | b = k)$, $\theta_j^k > \rho_j$ if $k = j$ and $\theta_j^k < \rho_j$ otherwise, and $\sum_j \theta_j^k = 1$.²¹ Finally, I assume that $E(\eta | b = h) > E(\eta | b = m) > E(\eta | b = l)$.

²¹For example, a person with $b = h$ receives the signal $\{\theta_h^h, \theta_m^h\}$, where $\theta_h^h > \rho_h$, $\theta_m^h < \rho_m$, and $1 - \theta_h^h - \theta_m^h < 1 - \rho_h - \rho_m$. Thus the person with $b = h$ is more likely than a randomly selected person to be an η_h type and less likely to be η_m or η_l types.

This model conditions on college graduation, so agents make two decisions.²² The first decision is the amount of effort to exert in college. Students choose between two levels of effort— e_h and e_l , or high and low—and while effort is not observable to employers, it determines GPA, G , which is observable. Students choosing high effort earn $G = G_h$, while those who choose low effort earn a GPA of $G = G_l$. I normalize $G_h = 1$ and $G_l = 0$. All students who attend college, regardless of effort, learn their type upon graduating. Finally, while high effort yields the same GPA for all people, the cost of this effort differs by type. People with $\eta = \eta_j$ incur a cost, c_j^e , from choosing high effort, where $c_l^e > c_m^e > c_h^e$. In other words, individuals with higher η have a lower cost of choosing high effort, and if a person chooses not to make an effort to earn a high GPA, no cost is incurred.²³ Finally, graduate schools admit all applicants with $G = 1$, but only a fraction λ with $G = 0$ is admitted.²⁴

The second decision agents make relates to graduate school. This decision is made after graduating college.²⁵ Agents can choose to either invest or not invest in graduate school. They choose $S = 1$ and sit out of the labor market for one period in the former case and choose $S = 0$ and enter the labor market in the latter. A worker with $G = 0$ can also choose $S = 1$ but be rejected from graduate school; in this case he will enter the labor market. If a person invests in graduate school, the cost is c_j^s for type η_j , and $c_l^s > c_m^s > c_h^s$. Again, higher ability agents have a lower cost of investing in school, and no cost is incurred for people who do not invest in graduate

²²A more general model could allow students to choose between completing some college and completing a bachelor's degree, and achievement and learning about η could potentially impact this decision. I restrict the model to only consider college graduates since the data in this paper only samples college students in their final year who are planning to graduate.

²³One can think of this cost as a time cost. While all agents, regardless of type, can earn high grades, lower types need to spend more time in order to do this relative to higher types.

²⁴One can think of λ as follows: graduate schools screen along multiple dimensions, only one of which is grades. For the students with low grades in college, there may be other factors that make them attractive applicants. Suppose that graduate schools screen on X from the previous section for the students with $G = 0$, and all applicants with $X > X^*$ are admitted. Then $\lambda = Pr(X > X^* | G = 0)$.

²⁵In the data, most respondents do not go directly to graduate school after college. In the model, I make the simplifying assumption that college graduates do not work between college and graduate school. If there is no learning by employers about η , this assumption is without loss of generality. Several papers have found evidence that employers do learn about η (Farber and Gibbons (1996), Altonji and Pierret (2001), Lange (2007), and Kahn (2009)). These papers treat test scores that employers cannot observe (such as the AFQT) as a measure of η , and they typically find that the return to these tests grows as workers gain more experience – presumably as employers learn about initially unobservable characteristics correlated with the test scores. These studies focus on all workers, but Arcidiacono, Bayer, and Hizmo (2008) find that there is no change in the return to the AFQT for college graduates as they gain work experience, indicating that employers do not learn about η for the population of interest in this model.

school. Finally, I assume that $E(c^e|b = h) < E(c^e|b = m) < E(c^e|b = l)$.

Firms directly observe G and S , but they can only infer η based on workers' choices of effort and schooling. When a firm hires a worker, he produces $Y = \alpha G + \beta S + \eta$. There is a large number of firms that can enter and exit freely, and labor markets are perfectly competitive.

The timing of the model is as follows:

1. In Period 1, everyone is in school and nobody works in the labor market. Before any decisions are made, agents receive a signal about their η , b , and choose their effort level. This effort level results in GPA, G . By the end of Period 1, all agents privately learn their type.
2. At the beginning of Period 2, people decide whether to go to graduate school or to enter the labor market. If the student makes the decision to go to graduate school and is accepted, he sits out of the labor market for a period. If the person decides not to invest in or is rejected from graduate school, he enters the labor market. Agents who enter the labor market produce $Y = \alpha G + \eta$, but the labor market does not observe each individual's Y . Only total firm productivity, G , and S are known, so the labor market does not observe each individual's η .²⁶
3. All agents go to the labor market. Each person produces $Y = \alpha G + \beta S + \eta$, but the labor market can only observe firm-wide productivity and agent decisions about G and S .

6.1 Equilibrium

The equilibrium of this model depends on its parameterization, and I will focus on a particular separating equilibrium that fits the empirical results in the previous section well. This is an equilibrium in which some people choose to work hard during college, some choose not to; some people choose to go to graduate school while others choose not to. Specifically, I study the equilibrium where agents with $b = h$ and $b = m$ choose high effort in college but agents with

²⁶From the econometrician's point of view, this assumption can be relaxed to allow the labor market to learn about the η of people who go directly to the labor market. So long as η is initially unobservable and students use GPA to signal η early in their careers, a regression of wages on GPA that does not control for η will still estimate the "signaling effect" of GPA. See for example Farber and Gibbons (1996) and Altonji and Pierret (2001).

$b = l$ choose low effort. η_h types attend graduate school, but η_m and η_l types enter the labor market directly after college. In order to derive the conditions for the separating equilibrium, I work backwards from Period 3.

In the third period, competition for workers and free entry and exit yield wages that are equal to expected productivity given earlier decisions. Since only η_h types choose $S = 1$, $E(\eta|S = 1) = \eta_h$. This implies that earnings, $w_3 = E(Y|G, S)$, are

$$w_3 = \begin{cases} \alpha G + \beta + \eta_h & \text{if } S=1 \\ \alpha G + E(\eta|G, S = 0) & \text{if } S=0 \end{cases} \quad (6)$$

At the beginning of Period 2, students decide whether to attend graduate school. Students learn their types at the end of Period 1 and invest in graduate school if the net payoff from investing in graduate school exceeds the payoff from not investing. If only η_h types invest in graduate school, the payoff from attending graduate school for type η_j is $\alpha G + \beta + \eta_h - c_j^s$. Since workers spend two periods in the labor market if they choose to not attend graduate school, the payoff from not earning a graduate degree is $2[\alpha G + E(\eta|G, S = 0)]$. Therefore only η_h types invest in graduate school if

$$\alpha G + \beta + \eta_h - c_h^s \geq 2[\alpha G + E(\eta|G, S = 0)] \quad (7)$$

and medium and low types do not if

$$\alpha G + \beta + \eta_h - c_j^s < 2[\alpha G + E(\eta|G, S = 0)] \quad (8)$$

for $j = m, l$.

Rearranging and combining Equations (7) and (8) leads to the following condition:

$$c_h^s \leq \beta + [\eta_h - 2E(\eta|G, S = 0)] < c_m^s \quad (9)$$

for $G = 1, 0$ and $k = h, m, l$. Only η_h types will choose to go to graduate school if they are the

only type for which the benefits of going to graduate school outweigh the costs.

In Period 1, students choose high effort if the expected payoff from high effort is larger than the expected payoff from low effort given the choices of others. Suppose only students with $b = h$ and $b = m$ choose high effort, and students with $b = l$ choose low effort. Let $w(e, b) = E(w_2 + w_3|e, b)$ – that is, the expected sum of wages given choice of effort, e , and beliefs, b . Given the results from Periods 2 and 3 and the choices of other students, the expected sum of period 2 and 3 wages from choosing high effort is

$$w(e_h, k) = (2 - \theta_h^k)\alpha + \theta_h^k(\beta + \eta_h - c_h^s) + 2(1 - \theta_h^k)E(\eta|G = 1, S = 0).$$

The first component, $(2 - \theta_h^k)\alpha$, is the expected human capital payoff to effort. The second component, $\theta_h^k(\beta + \eta_h - c_h^s)$, accounts for the possibility that a student learns she is a high type and goes to graduate school. Finally, $2(1 - \theta_h^k)E(\eta|G = 1, S = 0)$ can be thought of as the signaling payoff to effort. If a worker chooses high effort, employers use his academic achievement and decision not to return to school to form expectations about η , and this signaling payoff is received for two periods. Note that this payoff is only received if the student does not attend graduate school. Since the expected cost of choosing high effort is $E(c^e|b = k)$ for someone with beliefs $b = k$, the expected payoff to choosing high effort is $w(e_h, k) - E(c^e|b = k)$. The payoff to choosing low effort is

$$w(e_l, k) = \theta_h^k[\lambda(\beta + \eta_h - c_h^s) + 2(1 - \lambda)E(\eta|G = 0, S = 0)] + 2(1 - \theta_h^k)E(\eta|G = 0, S = 0). \quad (10)$$

The first term here reflects the possibility that, by earning a low GPA, some high ability workers will be rejected from graduate school and therefore be unable to earn a graduate degree. The second term reflects the possibility that some workers will not be high productivity workers *ex post*. Therefore, those with beliefs $b = h, m$ will choose high effort and those with beliefs $b = l$

will choose low effort if the following set of inequalities hold:

$$\begin{aligned}
E(c^e|b = h) &\leq (2 - \theta_h^h)\alpha + \theta_h^h(1 - \lambda)[(\beta + \eta_h - c_h^s) - 2E(\eta|G = 0, S = 0)] + \\
&\quad 2(1 - \theta_h^h)[E(\eta|G = 1, S = 0) - E(\eta|G = 0, S = 0)] \\
E(c^e|b = m) &\leq (2 - \theta_h^m)\alpha + \theta_h^m(1 - \lambda)[(\beta + \eta_h - c_h^s) - 2E(\eta|G = 0, S = 0)] + \\
&\quad 2(1 - \theta_h^m)[E(\eta|G = 1, S = 0) - E(\eta|G = 0, S = 0)] \\
E(c^e|b = l) &> (2 - \theta_h^l)\alpha + \theta_h^l(1 - \lambda)[(\beta + \eta_h - c_h^s) - 2E(\eta|G = 0, S = 0)] + \\
&\quad 2(1 - \theta_h^l)[E(\eta|G = 1, S = 0) - E(\eta|G = 0, S = 0)]. \tag{11}
\end{aligned}$$

If the return to effort is larger than its expected cost, students choose high effort. Otherwise, they choose low effort. Note that the return to effort is potentially due to both human capital and to screening as well as to an option value of graduate school, since earning high grades increases the likelihood of earning a graduate degree. The separating equilibrium is defined by Equations (9) and (11).

In what follows, let $\Delta E(Z|G) = E(Z|G = 1) - E(Z|G = 0)$ for some variable Z . The model and this equilibrium have four features that provide a lens through which to view the results in Section 4:

1. A regression of log earnings on GPA estimates the following term:

$$\Delta E(w_3|G) = \alpha + \beta\Delta E(S|G) + \Delta E(\eta|G). \tag{12}$$

The estimate of the effect of GPA on earnings for the entire sample consists of three components. First, it includes the effect of GPA on productivity, α . Second, the term $\beta\Delta E(S|G)$ accounts for the fact that individuals with higher GPAs are more likely to go to graduate school than those who choose low effort. Third, $\Delta E(\eta|G)$ reflects that employers use GPA to screen workers and that GPA is positively associated with graduate school attendance (which in turn is used to screen workers).²⁷ A regression of earnings on GPA therefore esti-

²⁷To see this, note that

$$\Delta E(\eta|G) = \eta_h\Delta Pr(S = 1|G) +$$

mates the effect college achievement (1) on productivity, (2) on earnings through graduate school (due to both graduate school's effect on productivity and screening), and (3) on earnings through its use to screen workers. Recalling from Section 4 that a one point increase in GPA is associated with a 9% increase in earnings, this coefficient can be interpreted as reflecting the relationship between college achievement and graduate school completion, the role achievement plays in augmenting human capital, and/or the use of GPA by employers to screen workers.

2. The estimate of the effect of GPA on earnings for those who choose $S=0$ is

$$\Delta E(w_t|G, S = 0) = \alpha + \Delta E(\eta|G, S = 0). \quad (13)$$

for $t = 2, 3$. This estimate reflects the effect of GPA on earnings due to its effect on productivity (α) and its use as a screen by employers ($\Delta E(\eta|G, S = 0)$).

3. The estimate of the effect of GPA on earnings for those who choose $S=1$ is

$$\begin{aligned} \Delta E(w_3|G, S = 1) &= \alpha + \Delta E(\eta|G, S = 1) \\ &= \alpha. \end{aligned} \quad (14)$$

This estimate only reflects the effect of GPA on productivity because graduate degree holders credibly signal high ability by earning a graduate degree.

4. One can estimate the signaling/screening effect of achievement by subtracting Equation (14) from (13):

$$\Delta E(w_3|G, S = 0) - \Delta E(w_3|G, S = 1) = \Delta E(\eta|G, S = 0) \quad (15)$$

The third point follows from two features of this separating equilibrium. First, GPA is a noisy signal of η . Students are uncertain about their types when the effort decision is made, so some

$$[\Delta E(\eta|G, S = 0)Pr(S = 0|G) + \Delta Pr(S = 0|G)E(\eta|G, S = 0)].$$

students who have a low η will choose high effort and do well in college while others who have a high η will make the same decision. Second, high productivity types are able to effectively signal that they have $\eta = \eta_h$ through graduate school. Since employers can use GPA and graduate school to infer the same parameter, in the case of graduate degree holders the signal that reveals ability (graduate school) is used instead of the noisy signal (GPA). Employers therefore only price the productivity effect of GPA into earnings. On the other hand, the decision to not attend graduate school does not perfectly reveal ability, so GPA is still used to screen workers with no graduate degree.

Viewing the results from Section 4 in light of this model, the zero GPA-earnings relationship for graduate degree holders and the fairly large, positive relationship for respondents without a graduate degree would suggest that most of the GPA-earnings relationship is driven by signaling rather than human capital.²⁸ Recalling Columns (2) and (3) of Table 6, the estimate of α_1 (the GPA-earnings relationship for graduate degree holders or “human capital effect”) is approximately -0.01 and statistically insignificant, while the estimate of α_2 (the difference in the GPA-earnings relationship for those with and without graduate degrees or “signaling effect”) is between 0.058 and 0.065 and significant at the 1% level.

7 Robustness Checks

In this section I consider alternative explanations for the results in Section 4. Additionally, I include several specification tests to examine the robustness of the results.

²⁸As mentioned earlier, Arcidiacono, Bayer, and Hizmo (2008) find that the AFQT-earnings relationship does not grow for college graduates as they accumulate more labor market experience. Based on this result, the authors argue that undergraduate credentials reveal ability rather than signal it. I do not believe that the empirical and theoretical results from this paper are inconsistent with the results and interpretations in their paper. First and most importantly, while my analysis is conducted conditional on earning a bachelor’s degree, I am only focusing on the contribution of one component of the college credential. Undergraduate institution, major field of study, and extra curricular activities also likely play a role in signaling or revealing ability to employers. Second, AFQT is only one dimension of ability. It is possible that college credentials reveal cognitive ability but only signal other traits that are also important in wage determination.

7.1 Functional Form and Variation in Dependent and Explanatory Variables

It is possible that I find no relationship between GPA and earnings for respondents with a graduate degree because there is little variation in achievement or earnings within this group. Table 7 presents the standard deviation in earnings and GPA for graduate degree holders and for respondents with no graduate degree. The standard deviation of GPA for those with only a bachelor's degree is 0.479 while it is 0.439 for the sample of respondents with a graduate degree, and the standard deviation does not differ very much by college rank. Similarly, the standard deviation of log earnings for those with only a bachelor's degree is 0.676 while it is 0.605 for the entire sample. A lack of variation in the dependent and independent variables does not appear to explain the zero relationship between GPA and earnings among graduate degree holders.

Since the GPA distribution of graduate degree holders is shifted to the right of the distribution for the entire sample,²⁹ another possible explanation for the results in Section 4 is that the relationship between GPA and earnings is non-linear. If, for example, the relationship is zero beyond a sufficiently high level of GPA, and a high fraction of graduate degree holders have a GPA above that threshold, there would be an estimated zero effect of GPA on earnings for this group of respondents.

This is unlikely, since nearly 75% of graduate degree holders earned less than a 3.53 GPA and half earned less than a 3.23 (about a B+ and B average, respectively). However, it is still of interest to test the assumption that the GPA-earnings relationship is log-linear, so I estimate the following regression using wages and experience 10 years after graduating college:

$$w_i = \alpha_1 1[G_i < 2.5]G_i + \alpha_2 1[2.5 \leq G_i < 3.0]G_i + \alpha_3 1[3.0 \leq G_i < 3.5]G_i + \alpha_4 1[3.5 \leq G_i]G_i + X_i\beta' + f(EXP_i) + \epsilon_i. \quad (16)$$

Figure 1 displays results from this regression. The assumption of a linear relationship between GPA and log earnings seems reasonable in this case, so it is unlikely that non-linearities in the

²⁹This result is not shown but available upon request.

GPA-earnings relationship are driving the results.

Another concern may be that certain undergraduate degrees increase productivity while others do not. For example, engineering and science majors may learn skills that are particularly useful for the occupations they are likely to enter into, whereas there is less of a direct connection between course material for a humanities major and the labor market. Accordingly, the first column of Table 8 presents results from a regression that interacts GPA with a dummy variable that equals one if a respondent studied a science- or engineering-related field. I restrict the sample to graduate degree holders in order to isolate heterogeneity in the GPA-earnings relationship within this group. Science majors on average see a higher return to achievement than other students, but this estimate is quite noisy and statistically insignificant.

Relative to the entire sample, a higher fraction of graduate degree holders attended a first or second tier school in college. If college achievement is a relatively less important determinant of earnings at top universities, the results from Section 4 may reflect this weaker GPA-earnings relationship. Column (2) re-runs the regressions from Section 4 on the sample of respondents from outside the first and second tiers. The results do not differ much from those in Table 6, so it does not appear that differences in the samples with and without graduate degrees are driving results.

Finally, many respondents with a graduate degree have a degree in education. If most people with an education degree become educators, and this occupation has relatively little variation in earnings, this could lead to an understatement of the relationship between GPA and earnings among all graduate degree holders. Column (3) presents results from a regression that allows the relationship between GPA and earnings to differ by whether a respondent's graduate degree is in education. For respondents with a graduate degree in a non-education field, there is no relationship between GPA and earnings. For respondents with a graduate degree in education there is a slightly negative relationship between GPA and earnings. This estimate is significantly different from the GPA-earnings relationship for non-education graduate degree holders at the 10% level. In any case, the respondents with education degrees do not appear to lead to a significant understatement of the GPA-earnings relationship for graduate degree holders.

7.2 Endogeneity of Labor Market Experience

A potential problem with interpreting the results from Table 2 as the causal effect of college GPA on earnings is that post-college labor market experience is an endogenous variable that may be affected by college GPA. As was discussed above (in the case of highest degree attained), even if GPA is uncorrelated with the error term, if a common unobserved factor determines both experience and earnings, the above results may be biased.³⁰

In order to deal with this problem, I follow Altonji and Shakotko (1987) by using de-meaned experience as an instrument for experience. That is, I use the variables $EXP_{it} - \overline{EXP}_i$ and $EXP_{it}^2 - \overline{EXP}_i^2$ as instruments for EXP_{it} and EXP_{it}^2 . As Altonji and Shakotko note, these variables are mean independent of the fixed portion of the error term by construction.

Table 9 displays results from these IV regressions. The estimated coefficients on GPA , EXP and EXP^2 are quite similar in both the OLS and IV models. Column (1) repeats the estimates from Column (3) of Table 2. In that model, a one point increase in GPA is associated with a 9% increase in earnings, and the coefficients on EXP and EXP^2 are 0.117 and -0.003. Column (2) of Table 9 presents the IV results. In this specification a one point increase in GPA is associated with a 9.5% increase in earnings, and the coefficients on EXP and EXP^2 are 0.137 and -0.003, respectively. While experience could be a “bad control” in theory, it does not appear to bias the results in this case.

7.3 Variation in the GPA - Earnings Relationship

The above results assume that the relationship between GPA and earnings does not vary by background characteristics. To the extent that college achievement may mean something different for different people, it is worthwhile to examine whether the relationship between GPA and earnings varies according to respondents’ observable characteristics. Table 10 presents evidence on heterogeneity in the relationship between GPA and earnings across different groups of respon-

³⁰In fact, because the labor supply of college graduates is so high, the endogeneity of experience and highest degree are close to two sides of the same coin—respondents with higher GPAs are more likely to go graduate school than their peers with lower GPAs, and at a given point in time for a particular cohort, those with the higher levels of education will on average have lower levels of labor market experience.

dents. The first column allows the relationship between GPA and earnings to vary by gender. The relationship between GPA and earnings for women is about 3.6 percentage points larger than for men, but this difference is not significantly different from zero. The difference in the return to achievement for non-white respondents is 6.4 percentage points larger than for white respondents, and once again this difference is not statistically different from zero at conventional levels.

The third column allows the return to achievement to vary by college rank. Due to small sample sizes, the first and second tier schools are grouped together, as are fourth and fifth tier schools. There appears to be a very large relationship for respondents graduating from first, second, and sixth tier schools: a one point increase in GPA is associated with a 15% increase in earnings ten years after college for those graduating from first and second tier schools; the GPA-earnings relationship for sixth tier graduates is not much smaller and statistically no different from the estimate for first tier college graduates. The GPA-earnings relationship for students graduating from third tier colleges and universities is 13.4 percentage points lower than their peers graduating from first and second tier universities, and this difference is statistically significant at the 5% level. Finally, fourth tier respondents have a GPA-earnings relationship that is 9.7 percentage points lower than their first and second tier peers, though this is not statistically different from first and second tier respondents at conventional levels. Thus there appears to be some heterogeneity in the GPA-earnings relationship by school rank, though given the similar relationship for first and sixth tier respondents there isn't a clear monotonic relationship between the size of the relationship and school rank.

Finally, the fourth column allows the relationship between GPA and earnings to vary by parents' income. Respondents with parents in the bottom quartile of the income distribution (within this sample) have a return to college achievement that is quite close to that of the respondents with parents in the middle 50% of the income distribution and in the top quartile of the distribution.

While there is some variation in the return to college achievement across different groups, the only case where there are large and significant differences is in the case of school rank.

8 Conclusion

Success in school is widely viewed by both students and policy makers as an important determinant of labor market outcomes later in life, and accordingly a considerable amount of time and money is spent in order to raise student achievement. I find that the private returns to these investments are quite large and statistically significant: a one point increase in GPA is associated with about a 9% increase in earnings.

To gain a better understanding of the GPA-earnings relationship, I investigate whether GPA is indirectly related to earnings through graduate school. If the relationship is driven by graduate attainment, then one would expect (1) that net of highest degree earned there is little relationship between GPA and earnings for the entire sample and (2) that the relationship between GPA and earnings is small for respondents with no graduate degree. While I find support for the first point, the GPA-earnings relationship is positive and significant for respondents with no graduate degree but close to zero and insignificant for graduate degree holders. Thus it appears that graduate attainment does not completely explain the GPA-earnings relationship.

I reconcile these results through a model in which GPA and graduate school can both increase productivity and signal ability. The model highlights the idea that employers rely on the most recent educational credential to screen potential employees. Employers therefore do not use undergraduate GPA to infer graduate degree holders' unobserved ability but do use undergraduate GPA to screen potential employees without a graduate degree. In contrast, if GPA increases productivity, it will do so for workers regardless of post-college educational attainment. The return to GPA for graduate degree holders primarily reflects the productive effect of achievement while it reflects both the productive and signaling effect for people without a graduate degree.

The equilibrium studied therefore suggests that the results are consistent with the hypothesis that the return to achievement is mostly driven by signaling. The GPA-earnings relationship for graduate degree holders is close to and not statistically different from zero, while the relationship is large and statistically significant for people with no graduate degree.

If college achievement is only used to sort workers into jobs, a policy in which financial aid is tied to achievement may be of ambiguous social value. For example, in the case where

all college students are equally exposed and respond similarly to the policy, there may be no improvement in sorting and therefore no social return. If only certain populations are targeted, overall productivity could be increased, decreased or unchanged depending on whether the policy leads to achievement doing a better or worse job sorting students into jobs.

On the other hand, the results suggest that policy makers could improve sorting into jobs by improving access to graduate school. If there are some high ability students who cannot attend graduate school because of credit constraints, a policy of relatively cheap loans for graduate school (such as is available in the U.S.) could allow all high types to signal their productivity to the labor market.

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Table 1: Sample Statistics

Variable	Mean	Variable	Mean
GPA	3.03	Highest Degree (by 2003)	
College Rank		Bachelor's	0.72
First Tier	0.07	Master's	0.21
Second Tier	0.09	Professional	0.05
Third Tier	0.17	Doctoral	0.02
Fourth Tier	0.13	Race/Ethnicity	
Fifth Tier	0.07	American Indian/Alaska Native	0.00
Sixth Tier	0.47	Asian/Pacific Islander	0.04
Father's Education		Black, Non-Hispanic	0.05
High School or Less	0.33	Hispanic	0.04
Some College	0.17	White, Non-Hispanic	0.86
College or More	0.50	Gender	
Mother's Education		Male	0.46
High School or Less	0.39	Female	0.54
Some College	0.22	Parent's Income (in 1992 Dollars)	
College or More	0.40	Sample Average	\$54,417
Education, National Average*		National Average**	\$22,901
High School or Less	54.10	Occupation	
Some College	22.80	Educator	0.10
College or more	23.10	Business and Management	0.30
Graduate Degree Field		Engineering/Architecture	0.06
Arts and Humanities	0.08	Computer Science	0.06
Social and Behavioral Sciences	0.09	Medical Professional	0.11
Life and Physical Sciences	0.05	Editor/Writer/Performer	0.06
Engineering/Math/Comp Sci	0.10	Human/Protective Service/Legal Profession	0.10
Education	0.13	Research/Scientist/Technical	0.04
Business and Management	0.20	Admin/Clerical/Legal Support	0.04
Medicine/Health	0.13	Mechanic/Laborer	0.02
Law	0.12	Service Industry	0.10
Other	0.11	Other/Military	0.01

* Source: Statistical Abstract of the United States

** Source: Bureau of Labor Statistics, Current Employment Survey

Table 2: Achievement and Earnings

N = 4577

	(1)	(2)	(3)	(4)
GPA	0.079 [0.028]***	0.083 [0.023]***	0.090 [0.023]***	0.094 [0.023]***
Second Tier		-0.058 [0.067]	0.005 [0.068]	
Third Tier		-0.129 [0.062]**	-0.057 [0.064]	
Fourth Tier		-0.195 [0.066]***	-0.115 [0.066]*	
Fifth Tier		-0.201 [0.071]***	-0.100 [0.073]	
Sixth Tier		-0.300 [0.063]***	-0.183 [0.065]***	
Father's High Degree is High School			0.027 [0.030]	0.043 [0.031]
Father's High Degree is at least Bachelor's			0.042 [0.028]	0.048 [0.025]*
Mother's High Degree is High School			0.005 [0.028]	-0.002 [0.027]
Mother's High Degree is at least Bachelor's			-0.003 [0.026]	-0.018 [0.027]
Family Income			0.023 [0.011]**	0.030 [0.011]***
Male			0.282 [0.024]***	0.281 [0.025]***
White			0.012 [0.035]	-0.024 [0.037]
SAT/ACT Score			0.001 [0.001]	0.000 [0.000]
Experience	0.139 [0.049]***	0.125 [0.046]***	0.117 [0.044]***	0.110 [0.043]**
Experience ²	-0.003 [0.003]	-0.002 [0.003]	-0.003 [0.003]	-0.002 [0.003]
Constant	9.317 [0.212]***	9.715 [0.204]***	9.804 [0.354]***	9.909 [0.355]***
R-squared	0.06	0.14	0.19	0.29
School Rank Controls	No	Yes	Yes	No
Major Controls	No	Yes	Yes	Yes
School Fixed Effect	No	No	No	Yes
Background Controls	No	No	Yes	Yes

Note: Standard errors clustered by FICE code are in brackets. * Significant at the 10% level, ** at the 5% level, *** at the 1% level. First Tier is the omitted category for school rank dummies. BA Major categories are Education, Engineering, Health Professions, Public Affairs, Biological Sciences, Math/Science, Social Science, History, Humanities, Psychology, and Other. Business and Management is the excluded category. All regressions are weighted by the 2003 sample weight.

Table 3: Relationship Between GPA and Background Characteristics

	N = 4629					
	(1)	(2)	(3)	(4)	(5)	(6)
25th-75 Income Percentile	-0.051 [0.026]**	-0.050 [0.026]*	-0.048 [0.025]*	-0.049 [0.025]*		
Top Income Quartile	-0.061 [0.025]**	-0.056 [0.026]**	-0.051 [0.026]**	-0.051 [0.026]**		
Family Income (\$50,000)					-0.017 [0.006]***	-0.009 [0.006]
Male	-0.162 [0.019]***	-0.162 [0.019]***	-0.136 [0.019]***	-0.136 [0.019]***	-0.137 [0.018]***	-0.117 [0.019]***
SAT/ACT Score	0.006 [0.000]***	0.006 [0.000]***	0.007 [0.000]***	0.007 [0.000]***	0.007 [0.000]***	0.008 [0.000]***
Age at Graduation	-0.097 [0.013]***	-0.098 [0.013]***	-0.104 [0.014]***	-0.104 [0.013]***	-0.103 [0.013]***	-0.114 [0.011]***
White	0.181 [0.033]***	0.181 [0.033]***	0.163 [0.033]***	0.162 [0.033]***	0.161 [0.032]***	0.137 [0.032]***
Mom has Some College	-0.025 [0.031]	-0.017 [0.032]	-0.021 [0.030]			
Mom has College or More	-0.037 [0.023]*	-0.024 [0.025]	-0.026 [0.023]			
Dad Has Some College		-0.020 [0.028]		-0.024 [0.027]	-0.026 [0.027]	-0.014 [0.025]
Dad Has College or More		-0.030 [0.023]		-0.030 [0.021]	-0.027 [0.021]	-0.017 [0.019]
Second Tier			-0.046 [0.070]	-0.045 [0.070]	-0.046 [0.069]	
Third Tier			0.021 [0.037]	0.019 [0.036]	0.018 [0.035]	
Fourth Tier			0.104 [0.046]**	0.104 [0.044]**	0.100 [0.043]**	
Fifth Tier			0.106 [0.042]**	0.105 [0.041]**	0.104 [0.041]**	
Sixth Tier			0.121 [0.037]***	0.120 [0.036]***	0.119 [0.035]***	
R-squared	0.21	0.21	0.23	0.23	0.23	0.44

Note: Standard errors clustered by FICE code are in brackets. * Significant at the 10% level, ** at the 5% level, *** at the 1% level. First Tier is the omitted category for school rank dummies. BA Major categories are Education, Engineering, Health Professions, Public Affairs, Biological Sciences, Math/Science, Social Science, History, Humanities, Psychology, and Other. Business and Management is the excluded category. All regressions are weighted by the 2003 sample weight.

Table 4: Return to Graduate Degree Attainment

	N=4397		
	(1) OLS	(2) OLS	(3) FE
Master's Degree	0.320 [0.028]**	0.076 [0.027]**	0.237 [0.037]**
Professional Degree	0.582 [0.058]**	0.393 [0.057]**	0.626 [0.114]**
Doctoral Degree	0.575 [0.061]**	0.253 [0.054]**	0.692 [0.103]**
R-squared	0.04	0.37	0.51
School Rank Controls	No	Yes	No
Major Controls	No	Yes	No
Background Controls	No	Yes	No
Person Fixed Effect	No	No	Yes

Note: Standard errors, clustered by FICE in Column (1) and by person in Columns (2) - (4), are in brackets.* Significant at the 10% level, ** at the 5% level, *** at the 1% level. First Tier is the omitted category for school rank dummies. BA Major categories are Education, Engineering, Health Professions, Public Affairs, Biological Sciences, Math/Science, Social Science, History, Humanities, Psychology, and Other. Business and Management is the excluded category. Background variables include mother's and father's college attainment, family income, race, gender, SAT/ACT scores, and age. Column (1) results are weighted by the 2003 sample weight and Columns (2) - (4) are weighted by the panel weights.

Table 5: GPA-Earnings Relationship Net of Highest Degree

	N = 4577			
	(1) OLS	(2) Two Stage	(3) Two Stage	(4) Two Stage
GPA	0.059 [2.48]**	-0.024 [0.023]	0.008 [0.023]	0.009 [0.026]
R-squared	0.21	0.09	0.14	0.27
School Rank Controls	Yes	Yes	Yes	No
Major Field of Study Controls	Yes	Yes	Yes	Yes
Demographic Controls	Yes	No	Yes	Yes
School Fixed Effect	No	No	No	Yes

Note: Standard errors clustered by FICE code are in brackets. * Significant at the 10% level, ** at the 5% level, *** at the 1% level. First Tier is the omitted category for school rank dummies. BA Major categories are Education, Engineering, Health Professions, Public Affairs, Biological Sciences, Math/Science, Social Science, History, Humanities, Psychology, and Other. Business and Management is the excluded category. All regressions shown are weighted by the 2003 sample weight. The first stage regressions are weighted by panel weights.

Table 6: GPA-Earnings Relationship by Graduate Degree Status

$N = 4577$

	(1)	(2)	(3)
GPA	-0.031	-0.007	-0.010
	[0.023]	[0.023]	[0.022]
No Grad Degree*GPA	0.053	0.058	0.065
	[0.008]***	[0.008]***	[0.007]***
R Squared	0.10	0.15	0.26
School Rank Controls	Yes	Yes	No
Major Field of Study Controls	Yes	Yes	Yes
Demographic Controls	No	Yes	Yes
School Fixed Effect	No	No	Yes

Note: Standard errors clustered by FICE code are in brackets. * Significant at the 10% level, ** at the 5% level, *** at the 1% level. First Tier is the omitted category for school rank dummies. BA Major categories are Education, Engineering, Health Professions, Public Affairs, Biological Sciences, Math/Science, Social Science, History, Humanities, Psychology, and Other. Business and Management is the excluded category. All regressions shown are weighted by the 2003 sample weight. The first stage regressions are weighted by panel weights.

Table 7: Standard Deviations

	Bachelor Degree Holders	All Graduate Degree Holders
Log Earnings	0.676	0.605
GPA		
Total	0.479	0.439
First Tier	0.430	0.396
Second Tier	0.506	0.431
Third Tier	0.459	0.445
Fourth Tier	0.487	0.420
Fifth Tier	0.463	0.477
Sixth Tier	0.484	0.448

Figure 1: Spline Results



Table 8: Alternative Specifications and Samples

	(1)	(2)	(3)
GPA	0.044 [0.051]	0.001 [0.023]	0.001 [0.022]
GPA*Science Major (Undergrad)	0.114 [0.131]		
GPA*No Graduate Degree		0.052 [0.009]***	0.054 [0.008]***
GPA*Education Graduate Degree			-0.031 [0.018]*
R-squared	0.13	0.15	0.15
Number of Observations	1290	3858	4577
Sample	Graduate Degree Holders	Students from 3rd through 6th tier universities	Whole Sample

Note: Standard errors clustered by FICE code are in brackets. * Significant at the 10% level, ** at the 5% level, *** at the 1% level. First Tier is the omitted category for school rank dummies. BA Major categories are Education, Engineering, Health Professions, Public Affairs, Biological Sciences, Math/Science, Social Science, History, Humanities, Psychology, and Other. Business and Management is the excluded category. All regressions weighted by the 2003 sample weight.

Table 9: Using De-Meaned Experience as Instrument for Experience

N = 4577		
	(1) OLS	(2) IV
GPA	0.090 [0.023]***	0.095 [0.024]***
Experience	0.117 [0.044]***	0.137 [0.066]**
Experience2	-0.003 [0.003]	-0.003 [0.004]

Note: Standard errors clustered by FICE code are in brackets. * Significant at the 10% level, ** at the 5% level, *** at the 1% level. Both regressions control for school rank, major field of study, mother's and father's college attainment, family income, race, gender, SAT/ACT score, and age. First Tier is the omitted category for school rank dummies. BA Major categories are Education, Engineering, Health Professions, Public Affairs, Biological Sciences, Math/Science, Social Science, History, Humanities, Psychology, and Other. Business and Management is the excluded category. Regressions are weighted by 2003 sample weights.

Table 10: Heterogeneity of Achievement-Earnings Relationship

N = 4577

	(1) Gender	(2) Race	(3) SQ	(4) Income
GPA	0.107 [0.035]***	0.080 [0.026]***	0.151 [0.048]***	0.087 [0.024]***
Male*GPA	-0.036 [0.047]			
Non-white*GPA		0.064 [0.062]		
Third Tier*GPA			-0.134 [0.059]**	
Fourth/Fifth Tier*GPA			-0.097 [0.061]	
Sixth Tier*GPA			-0.039 [0.059]	
Middle 50% Income Dist*GPA				0.004 [0.009]
Top Income Quartile*GPA				0.009 [0.013]
R-squared	0.19	0.19	0.19	0.19

Note: Standard errors clustered by FICE code are in brackets. * Significant at the 10% level, ** at the 5% level, *** at the 1% level. All regressions control for school rank, major field of study, mother's and father's college attainment, family income, race, gender, SAT/ACT score, and age. All interacted variables are included by themselves in the regressions, though results are not shown. First Tier is the omitted category for school rank dummies. BA Major categories are Education, Engineering, Health Professions, Public Affairs, Biological Sciences, Math/Science, Social Science, History, Humanities, Psychology, and Other. Business and Management is the excluded category. Regressions are weighted by 2003 sample weights.

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