College Quality and Early Adult Outcomes

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Abstract

This paper estimates the effects of various college qualities on several early adult outcomes, using panel data from the National Education Longitudinal Study. I compare the results using ordinary least squares with three alternative methods of estimation. I find that college quality does have positive significant effects on most outcomes studied using OLS. There is only modest evidence of positive selection bias in the OLS results. Two of methods find positive significant effects on men's earnings and men's and women's predicted future earnings, while all four specifications find consistent evidence of positive effects of several college qualities on educational attainment.

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1. Introduction

Given the potential effect of college quality on later life outcomes, mechanisms of access to high-quality post-secondary education are a fundamental social concern. However, considerable questions remain on whether, in fact, college quality has any causal effect on enrollees. Most of the studies on the effects of college quality have found that attending a highly selective institution increases earnings.[1] Causality is a particular problem for this literature due to selection on the part of both the student and the college. Recent findings have challenged the prior results. Dale and Krueger (2002) address the selection problem by matching students who were admitted to and rejected by institutions with similar qualities, to examine students with similar opportunity sets who make different decisions. They find no payoff to attending a college with a higher average SAT score (except for low-income students), but do find a payoff to attending a college with a higher net tuition. Their findings have some limitations. The dataset used for their main findings is restricted to enrollees at highly selective colleges, and thus the range of variation in college quality is limited.[2]

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[1] See James et al. (1989), Loury and Garman (1993, 1995), Behrman, Rosenzweig, & Taubman (1996), Daniel, Black, & Smith (1997, 2001), Bowen and Bok (1998), Hoxby (1998), Kane (1998), Brewer, Eide, & Ehrenberg (1999), and Monks (2000).

[2] The 1978 average SAT test score of the institutions that are included in their College and Beyond data ranges from Denison University (1,020) to Bryn Mawr College (1,370), and most are in a very narrow range (the median institutions being Wellesley University (1,220) and Georgetown University (1,225)). Dale and Krueger also use the National Longitudinal Study of the High School Class of 1972, which is nationally representative. However, they did not use their matching method on this dataset due to limitations in the sample size.

As a result, it is difficult to extrapolate their findings to broader differences in quality. Black and Smith (2004) critique the prior literature's use of linear parametric estimation models. As an alternative, they use a propensity score matching technique to estimate counterfactual outcomes for students that attended high quality colleges. They find positive significant effects of college quality on wages using an ordinary least squares specification, but insignificant effects of quality using their propensity score technique. However, for most of their estimates (particularly for men), the magnitude of the estimated results are nearly as large using either technique, while the standard errors are larger using the matching technique. These conflicting results in the literature motivate a fresh analysis of the sensitivity of the estimates to the methods used for estimation.

College quality is multi-dimensional, and attributes other than selectivity may have effects. For example, Monks (2000) finds that graduates from institutions that offer graduate degrees earn significantly more than other graduates. Additionally, college attributes may affect students' non-labor market outcomes. Bowen and Bok (1998) find that students at highly selective institutions are less likely to be divorced or separated than same-aged graduates of other colleges.

Using nationally representative data on recent college enrollees, this research will answer the following questions. First, are there significant wage premiums associated with attending a more selective college? Second, how do the estimates of these returns vary by the methods used for estimation? Third, what are the returns to other college attributes? Fourth, do we observe effects of college quality on other outcomes, including educational attainment and annual earnings?

I find the following. First, college quality does appear to have positive significant effects on most of the outcomes studied when estimated by ordinary least squares. There is only modest evidence of positive selection bias in these OLS estimates. Of the 162 estimates produced using three alternative methods, I find only 14 which are significantly different from the OLS estimates (at the two-tailed, 10% level of significance). Of these, exactly 7 are positive and 7 are negative.

Second, I find consistent evidence that a variety of college qualities have positive effects on educational attainment. This result is important, as it points to the importance of examining the educational production function as a complex process with many inputs that can each have effects on a variety of student outcomes. Finally, I find mixed evidence of significant effects of college quality on earnings, with OLS estimates tending to be positive and significant and non-OLS results tending to be insignificant. There appears to be stronger evidence for effects of college quality on men's earnings than on women's earnings. This result may not be surprising given the ages of the individuals studied, which coincide with the mean age of first birth for women with college degrees.[3] I find evidence for positive effects on both men's and women's predicted future earnings based on current education and occupation.

In the next section, I outline a model of the effect of college quality on outcomes. In Section 3, I discuss the data used for the empirical analysis and note how the qualities and outcomes examined relate to the model. In Section 4, I discuss the methods used to estimate the effects. Section 5 contains the results and Section 6 concludes.

2. Model for the Effect of College Quality

Students choose to attend college with the intent of bettering their life prospects. As enrollment in college is a costly endeavor for most students, those who choose to enroll in college must believe that college participation will raise their discounted lifetime utility. More formally, student *i* would prefer to attend the college that gives the highest expected indirect utility:

$$(2.1)\quad E(V_{ij}) > E(V_{i,-j})$$

[3] Using data from the National Longitudinal Survey of Youth (NLSY79), Amuedo-Durantes and Kimmel (2005) find that the mean age of first birth for women with a college degree was 26.3.

where E() is the expectation operator, V_{ij} is the indirect utility associated with attending college j and $V_{i,-j}$ is the indirect utility associated with attending a different college or not attending. This indirect utility is a function of the student's outcomes from attending college j ($\boldsymbol{Y}_{ij}$) and the student's costs of attending college j (C_{ij}). The student's outcomes given attendance at college j are a function of the college's qualities ($\boldsymbol{Q}_j$) and cost of attendance[4], the student's own attributes ($\boldsymbol{X}_i$), the student's family attributes ($\boldsymbol{F}_i$), and the student's neighborhood characteristics ($\boldsymbol{N}_i$):

(2.2) $\boldsymbol{Y}_{ij} = \mathrm{Y}(\boldsymbol{Q}_j, C_{ij}, \boldsymbol{X}_i, \boldsymbol{F}_i, \boldsymbol{N}_i)$

Thus, the student's indirect utility associated with attending college j is:

(2.3) $V_{ij} = \mathrm{V}[\mathrm{Y}(\boldsymbol{Q}_j, C_{ij}, \boldsymbol{X}_i, \boldsymbol{F}_i, \boldsymbol{N}_i), C_{ij}]$

Let $\boldsymbol{Q}_i$ and C_i denote the qualities and cost of the college attended by student i. The student's outcomes are given by the following:

(2.4) $\boldsymbol{Y}_i = \mathrm{Y}(\boldsymbol{Q}_i, C_i, \boldsymbol{X}_i, \boldsymbol{F}_i, \boldsymbol{N}_i)$

If the student had discretion to enter into the college of his choice, $\boldsymbol{Q}_i$ would equal $\boldsymbol{Q}_j^*$, where $\boldsymbol{Q}_j$* are the attributes of the college that maximizes E(V_i).

Estimating the effects of college qualities involves two challenges. First, the functional form of Equation 2.4 is unknown. Second, since the student's outcomes and $\boldsymbol{Q}_i$ are a function of student, family, and neighborhood characteristics, unobserved $\boldsymbol{X}_i$, $\boldsymbol{F}_i$, or $\boldsymbol{N}_i$, variables would lead to selection bias. Modifying the model to include selective college admissions would simply increase the potential selection bias problem, as the college may admit students on the basis of unobserved characteristics that may also affect the student's outcomes. In general, the concern is that these unobserved attributes are positively associated with both college quality and student outcomes. If so, estimates of the effect of college quality that omit unobserved traits would be biased positively.

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[4] Cost of attendance could affect the student's outcomes if higher costs require the student to take loans or work during college.

Third, measurement error in college quality would bias the estimated effects of college quality towards zero. Methods for dealing with these issues are discussed in Section 4.

College quality, ***Q***, can be broken down into three general types: quality and intensity of interactions with peers, quality and intensity of interaction with faculty, and other institutional qualities. Peer quality encompasses: peers' academic and social abilities; peers' connections with the world outside academia; and the student's compatibility with peers' traits and interests. Peer quality may also serve as a signal to employers and others when information about the student's own ability is limited. Faculty quality is a function of many characteristics, such as: degree of expertise; breadth of subject areas covered; and ability and willingness to convey knowledge, to develop learning skills, to motivate students' interest in learning, and to develop students' connections with employment opportunities and advanced education. Other institutional qualities include: enrollment size; proximity to amenities and cultural attractions; and academic and social resources (such as library facilities, athletic teams, etc). Thus, the treatment is very complicated.

Any analysis of the effect of college quality on later life outcomes must choose from a broad array of potentially important college qualities. Moreover, college quality can have effects on the students' lives in many ways, including on their educational attainment and learning, labor market outcomes, family formation, civic participation, and basic life satisfaction. Much of the literature has focused narrowly on the effects on hourly wages using only a few qualities (most frequently peer quality / selectivity). This paper broadens the list of examined qualities to include faculty quality, faculty availability, and exposure to graduate student peers. Likewise, I broaden the outcomes investigated to include educational attainment, own annual earnings, own plus spouse's annual earnings, and predicted future earnings. The qualities and outcomes included are discussed in more detail in the next section.

3. Data

Data are taken from the National Education Longitudinal Study (NELS), which sampled around 24 students each from approximately 1,000 public and private eighth grade schools throughout the nation. Data on these individuals were collected in 1988, 1990, 1992, 1994, and 2000. These data include 11,914 individuals interviewed in each of the last three rounds. At the time of the 2000 interview, the median age of this sample was 26 years old. As such, these data will provide an indication of the experiences of these individuals in early adulthood.

The following six outcomes are studied[5]:

1) Earned a bachelor's degree by 2000 (8 years after high school graduation).[6]
2) Student is attending or has attended graduate school by the year 2000.
3) Log of hourly earnings at the individual's current job or most recent job. The effects on this outcome are estimated separately for men and women using the sample of individuals who were not enrolled in college and who typically worked full-time (35 or more hours per week).
4) Annual earnings during 1999. This measure is inflated into 2000 dollars using the consumer price index. The effects on this outcome are estimated separately for men and women using the sample of individuals who were not enrolled in college.
5) Sum of the individual's annual earnings and his or her spouse/partner's annual earning during 1999. This measure is inflated into 2000 dollars using the consumer price index.

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[5] Additional information on how variables are constructed is included in the Appendix.

[6] In the academic year 1999-2000, 69% of U.S. bachelor's degree recipients were 24 years or younger, 14% were 25-29 years old, while only 17% were older than 29 (U.S. Department of Education, 2005). Thus, the NELS data will be able to capture most bachelor degree awards.

The effects on this outcome are estimated for those respondents with a spouse or partner and using the sample of individuals who were not enrolled in college.

6) Predicted weekly earnings at age 40 based on sex, race, education level, potential experience, and current occupation. This measure is constructed using data on individuals aged 35 to 45 in the 2000 Current Population Survey. See Appendix Table 1 for the specification and sample details. This measure is intended to capture the long run effects of college quality on earnings through its effects on these young adults' completed education and occupational choices.[7] The effects on this outcome are estimated separately for men and women using the sample of individuals who were not enrolled in college.

College quality is based on the first four-year college attended, as reported in the students' 1994 interviews. Thus, the results here should be interpreted as the effect of college quality for those students who enroll in a four-year college within two years of high school graduation.

The effects of six college qualities are evaluated:

1) Median freshman SAT test score. This measure is intended to capture the effects of both selectivity and peer quality. Data for this measure are taken from Barron's Profiles of American Colleges (1992).

[7] Betts (1996) employs a similar procedure, by estimating log weekly wages for white men aged 40 to 55 in the 1980 Census as a function of a number of variables including occupation and applying the resulting estimates to younger workers in the National Longitudinal Survey of Young Men. Controlling for years of education, Betts finds insignificant effects of secondary school quality on forecasted earnings.

2) List tuition minus average grants, loans, and work study. This measure is intended to capture the net price of attending this college for the average student. Data for this measure comes from American Universities and Colleges (1992) and the 1992 Integrated Postsecondary Education Data System (IPEDS). These first two measures of college quality are similar to the measures used by Dale and Krueger (2002).

3) Average full professor's salary adjusted for the local cost of living. This measure is intended to capture faculty quality. Data for this measure comes from the 1992 IPEDS.

4) Professors per student. This measure is intended to capture the effects of faculty availability, and may also signal smaller class sizes. Data for this measure comes from the 1992 IPEDS.

5) Graduate student share of total enrollment. A high share of graduate student peers could raise the student's aspirations to attend graduate school and may provide advisers who the student perceives as more accessible than faculty. A higher graduate student share may signal a university with a strong research reputation. On the other hand, a higher graduate student share could have adverse effects on the students if it indicates a larger number of classes taught by less experienced instructors. Data for this measure comes from the 1992 IPEDS.

6) Index of college quality. The index I use here is computed based on the above five measures, using the first principal component from a principal component analysis. As expected, this first principal component gives a positive weight to each of the above five measures. Based on this measure the top ten universities were the following: Cal Tech, Chicago, Columbia, Dartmouth, Harvard, Johns Hopkins, MIT, Princeton, Stanford, and Yale. This index was then normalized to have a zero mean and a standard deviation

equal to one. This measure of college quality is comparable to the approach taken by Black and Smith (2004).

A number of control variables are included in the OLS, IV, and Dale and Krueger specifications discussed in Section 4. These control variables capture factors that might be associated with attending a high quality college and also associated with the outcomes of interest. These control variables include student characteristics, family characteristics, neighborhood characteristics, and an index of high school quality.

Table 1 presents the descriptive statistics for the sample of students who attended a 4-year college by 1994.[8] This sample contains nearly 5,000 students. For comparison purposes, the last column contains the mean values for the sample of nearly 7,000 students who did not attend a 4-year college by 1994. By the year 2000, 66 percent of the included sample had earned a bachelor's degree, while, not surprisingly, only 7 percent of the excluded sample did so. That is, completion of a bachelor's degree is strongly correlated with attending a 4-year college within two years of high school graduation. These 4-year college enrollees earned higher hourly wages ($3.01 for men, and $3.58 for women), had higher annual earnings ($6,237 for men, and $10,447 for women), had higher predicted future weekly wages ($297 for men, and $251 for women), and higher family earnings ($10,999).

The 4-year college enrollees were markedly different on control variables as well. These enrollees were more likely to be female, non-Hispanic, non-black, come from an English speaking household, have married parents and parents with more education, have higher GPA and SAT

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[8] The NELS variable "f4f2pnwt" is used here to weight the means and standard deviations, and will be used in subsequent estimation. This weighting variable scales the 2000 sample of respondents to the 1992 population of high school seniors and accounts for the initial sampling scheme and non-response.

scores, have a lower number of siblings, and have notably higher parental income ($59,671 versus $34,585). Likewise, 4-year college enrollees came from better neighborhoods with better schools. Their neighborhoods had higher rates of adults with bachelors and graduate degrees, lower rates of unemployment, and higher income per capita. The average high school quality of enrollees was more than one-half standard deviation higher than that of non-enrollees.

4. Methods

One major contribution of this paper will be in comparing four methods to estimate the effects of college quality: ordinary least squares, instrumental variable, the Dale and Krueger (2002) method conditioning on observables and unobservables, and the semi-parametric method of Black and Smith (2004). Each method, as described below, has strengths and limitations.

4a. Ordinary Least Squares Method

The first method will be ordinary least squares of the following form:

$$(4.1) \quad y_i = q_i\beta + \boldsymbol{X}_i\gamma + \boldsymbol{F}_i\phi + \boldsymbol{N}_i\omega + \varepsilon_i$$

where y is the outcome of interest, q is a college quality, $\boldsymbol{X}$ is a vector of student attributes, $\boldsymbol{F}$ is a vector of family attributes, and $\boldsymbol{N}$ is vector of zip-code level neighborhood characteristics and high school quality. Note that this specification will include one outcome and one college quality at a time. Thus, given the nine outcomes and six college qualities, the equation be estimated a total of 54 times.[9]

[9] While it might be interesting to evaluate the effects of a vector of college qualities included in one specification, or to evaluate the interaction effects of various college qualities or non-linear specifications, these more complicated specifications are left for subsequent work. Further, it is reasonable to believe that some of the student's own, family, and neighborhood characteristics

With this OLS method, one should still be concerned that there may be an unobserved or non-included characteristic that is associated with both the student's college quality and outcome. If so, the estimate of β would be biased. However, a strength of the NELS data is the richness of the available control variables. By including the student's grade point average, test scores, high school quality, and parental and neighborhood education levels, the OLS specification is likely to capture most of the student's taste for education and school quality. Thus, the OLS specification findings should not be dismissed casually.

In the literature on the effects of years of education on wages, OLS estimates are found generally to be smaller than instrumental variable estimates (Card (1999)). A common interpretation is that measurement error biases the estimate of β downwards more than the upwards bias caused by omitted variables.[10] Such downward bias could be present in the OLS results here if college quality is mismeasured.

4b. Instrumental Variable Method

The second method is a traditional instrumental variable technique. To be a valid instrument, the variable must have a significant direct effect on college quality, while having no effect on the outcome of interest except through its effect on college quality. In the returns-to-education literature, scholars have had difficulty finding valid instruments. In a number of papers, beginning with Card (1995), college proximity has been used as an instrument for years of

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interact with college quality to affect outcomes. For example, the student likely benefits from some degree of academic fit with the institution. These interactions are not modeled here. Thus, the estimates of the effects of college quality should be considered valid only for the margins at which students in the data are making their application and enrollment decisions.

[10] See Griliches (1977) and Angrist and Krueger (1991).

education completed.[11] Theoretically, having a nearby college lowers the cost of attendance and thereby prompts students to obtain additional years of education. This use of proximity to instrument for years of education has been challenged (notably by Bound, Jaeger, and Baker (1995); and Staiger and Stock (1997)) because of its weak correlation with years of education. In effect, if proximity to college is to work in this context, the proximity of the college must influence the decision of some students to attend a college who otherwise would not. As it is unlikely that there are a large number of students who are at this enrollment margin, proximity fails as a strong instrument for years of education.

I use college proximity in a completely different way. I use the average quality (q) of colleges within a certain radius of the student as an instrument for the quality of the college at which the student attends, q. Because there is a cost to the student of attending college far away from home, students are more likely to attend nearby. Nearby high quality colleges lower the cost of obtaining a high quality college education. Even if students do not care about quality, if they choose to attend a nearby college and if colleges nearby are high quality, they are more likely to attend a high quality college by default. Thus the average quality of nearby colleges is likely to be correlated with the quality of the college actually attended.

One might be concerned that the presence of nearby high quality colleges could have direct effects on the student's outcomes, even if the student did not attend these colleges. This concern is particularly relevant for labor market outcomes, where the quality of the college could directly affect labor demand in the area. This concern should be mitigated by the inclusion of neighborhood characteristics, including unemployment, income per capita, and average educational attainment. If the proximate high quality colleges are having an effect on the local labor market, these effects

[11] See also Kane and Rouse (1995), Kling (2001), Lemke and Rischall (2003), and Currie and Moretti (2003).

should be captured by these neighborhood characteristics. To test the validity of the assumption that average quality of nearby colleges does not otherwise affect local labor market conditions, controlling for neighborhood characteristics, I ran the following regression on NELS students who ***did not*** enroll in a four-year college: $y_i = \overline{q}_i \beta + \boldsymbol{X}_i \gamma + \boldsymbol{F}_i \phi + \boldsymbol{N}_i \omega + \varepsilon_i$, where $\overline{q}_i$ is average nearby college quality for student *i*. This test was performed on the 54 combinations of outcomes and college qualities. Average nearby college quality was a significant predictor of the outcome in only 2 of the 54 regressions (at the 5% significance level). Of course, the labor markets for college entrants may be somewhat different, but the lack of evidence of effects for non-college entrants bolsters the confidence in this instrument.

To construct this instrument, I first find the distances that NELS students travel from their home school districts to their four-year colleges. I define the 75th percentile of this distance distribution as the radius of "nearby" colleges. For the NELS students, this radius is 176 miles. Second, I construct the instrument for *q* using the average quality of four-year colleges within this distance, weighted by their undergraduate enrollment. Thus, the first-stage instrument for college quality, *q*, is derived using estimates from the following regression:

$$(4.2) \quad q_i = \overline{q}_i \eta + \boldsymbol{X}_i \rho + \boldsymbol{F}_i \tau + \boldsymbol{N}_i \psi + \varepsilon_i$$

The instrumental variable is a strongly significant predictor of *q* for five of the six college qualities.[12] The exception is for "fraction of students who are graduate students," where the t-

[12] The t-statistics for the estimates of η are 7.10 for median freshman SAT score, 16.05 for average net tuition, 7.06 for relative full professor salary, 4.10 for professor-student ratio, 1.43 for graduate students' share of enrollment, and 7.76 for the index of college quality. These regressions are available on request. Do (2004) also finds that living near a quality public university increases the quality of college attended.

statistics for the estimated η is 1.43. Thus, less faith should be placed in the IV estimates for this college quality.

It is important to note that this instrumental variable strategy will be identifying the effect of college quality using those students who are least prone to travel a great distant to attend a high quality college. These students may be different from other students in ways that affect the estimates of the effect of college quality. For example, they may have lower aptitude than other college entrants. Thus, the resulting estimates should be understood as valid for those students whose enrollment decisions are sensitive to the quality of proximate colleges.

4c. Dale and Krueger (D-K) Method

The third method replicates the technique used by Dale and Krueger (2002), but expands it to a broader set of qualities and outcomes, and uses the method on a nationally representative group of students. I group students whose set of applications included similar quality colleges, and who were accepted and rejected by colleges with similar qualities. See the Appendix for a discussion of how "similar" is defined for each of the six college qualities. The premise behind this method is that students who have similar aspirations (as represented by their applications) and who have similar opportunities (as represented by their offers of admissions) will have similar unobservable characteristics. Thus, including a dummy variable for each similar group of students will absorb the effect of these omitted traits on the outcome of interest. The specification is as follows:

$$(4.3) \quad y_i = q_i\beta + \boldsymbol{X}_i\gamma + \boldsymbol{F}_i\phi + \boldsymbol{N}_i\omega + \boldsymbol{D}_i\delta + \varepsilon_i$$

where $\boldsymbol{D}$ is a vector of dummy variables for each similar group of students.

The vector of dummy variables is intended to eliminate the omitted variable bias on the estimate of β. However, because some students in a group choose to attend the higher quality colleges, and others the lower quality colleges, there is likely to be some remaining unobserved trait that prompts these differences in choice. If this remaining unobserved trait that leads to enrollment in the higher quality colleges (e.g., ambition) is positively correlated with the outcomes of interest, then the estimate of β would still be biased upwards. Thus, at best, this method purges most, but perhaps not all, of the positive selection bias in the estimate of β. On the other hand, this method could exacerbate the downward bias caused by measurement error in college quality (Griliches, 1979). For two students in a matched group, the one who chooses to attend the "lower quality" college may have some idiosyncratic reason why this college is a better fit such that it raises this student's returns from attending the "lower quality" college. Thus, the true quality of the "lower quality" college is higher for this student. Since that measurement error is likely to be negatively correlated with this student's later life outcomes (e.g., wages), the downward bias gets magnified. Therefore, it is not clear *a priori* whether this method will remove or exacerbate biases. Dale and Krueger acknowledge these potential problems.

Finally, note that students who submit only one college application and students who are alone in a group are dropped from this analysis. These two exclusions substantially reduce the sample size and change the focus to a specialized group of college applicants. I re-estimate the OLS specification on the same sample as included in the D-K specification to test the sensitivity of the results to sample selection.

4d. Black and Smith (B-S) Method

The fourth method replicates the technique used by Black and Smith (2004), again expanding its use to a broader set of qualities and outcomes. Black and Smith's method considers college quality as a treatment that is applied to some students and not to others. In this context, a student is considered "treated" if he or she attends a high-quality college. If we could observe a student in two states of the world, treated and untreated, then our estimate of the effect of the treatment for that student would simply be:

(4.4) $\beta_i = (y_i \mid treated_i{=}1) - (y_i \mid treated_i{=}0)$

Our estimate of the average effect of the treatment, β, would be the average of β_i. Since we don't observe the untreated outcomes for treated students, we must use the outcomes of untreated students as the counterfactual. If college quality were distributed to students at random, we could use the average outcome for untreated students as a counterfactual to the average outcome of treated students. However, this simple counterfactual is unavailable to us because college quality is not distributed randomly.

As a solution to this problem, Black and Smith use a propensity score matching technique to construct a counterfactual outcome for each treated student. A student is considered treated if she attends a top-quartile college, based on the value of q.[13] Untreated students are defined as those who attend a bottom-quartile college. Thus, the estimate of β should be interpreted as the average effect of attending a top-quartile college versus a bottom-quartile college. The counterfactual outcome for each treated student is computed using a weighted average of outcomes of untreated students with similar propensities to attend a top-quartile college. See the Appendix for details.

Table 2 shows the differences between the colleges attended by treated and untreated students. For each measure, there is a substantial difference between these colleges. For example, treated students attend colleges with quality indexes that are nearly 2.4 standard deviations better than the colleges that untreated students attend. Using the same sample of treated and untreated students, I compare the results of the B-S specification to the following OLS specification:

(4.5) $y_i = Treated_i\beta + \boldsymbol{X}_i\gamma + \boldsymbol{F}_i\phi + \boldsymbol{N}_i\omega + \varepsilon_i$

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[13] Black and Smith constructed an index of college quality using a principal component analysis on average faculty salary, average freshman SAT, and average freshman retention rate. For my analysis, colleges will be put into quartiles using one college quality (q) at a time. Quartiles are based on aggregate enrollment.

5. Results

Table 3a presents a summary of the estimates which are shown in Tables 4 through 9. The first column shows the pattern in the OLS results using the full sample of students who had attended a four-year college by 1994. In these results, there is a clear pattern of positive effects of the various college qualities. In total, 51 of the 54 estimated effects are positive and 32 of these are significant at the 10% level. In the second and third columns, I summarize the OLS results using the sample of individuals who are included in the D-K and B-S specifications. The general pattern of results is similar to the full sample results, showing generally positive effects. That is, using the smaller D-K and B-S samples does not change the basic character of the results. However, due to the smaller sample sizes in the D-K samples, the number of significant effects is reduced to 20 out of 54.

In the last three columns, I show the pattern of results for the IV, D-K, and B-S specifications. The IV and D-K specifications, which directly attempt to minimize selection bias, show generally insignificant effects of college quality – for the IV (D-K) specification 43 (50) of the 54 coefficients are insignificant. Moreover, one-third of the IV coefficients and two-fifths of the D-K coefficients are negative. These results are the strongest evidence of positive selection bias in the OLS results. The B-S specification finds very similar results to the OLS specification – 52 of the 54 estimated effects are positive and 31 of these are significant.

Table 3b shows whether the IV, D-K, and B-S coefficients are significantly different from the OLS specifications estimated on the same samples.[14] At the two-tailed, 10% level of significance, only 14 of the 162 estimates are significantly different from the OLS results – about the rate one would expect by chance. The evidence for *significant* bias is lacking.

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[14] For this calculation, I use the standard error on the estimated IV/D-K/B-S results to construct a confidence interval around the IV/D-K/B-S estimate.

The alternative specifications generally have higher standard errors than OLS, and thus lower rates of significance. Given the scant evidence for positive selection bias, relying on these methods to control for positive selection bias could lead to the faulty conclusion that measured college quality does not affect student outcomes. However, OLS estimates need to be taken with caution as well. Thus, in evaluating the parameter estimates, I will consider consistency in the results across the methods of estimation as stronger evidence of true effects.

Tables 4 through 9 contain the estimated effects of each college quality. It is important to remember that the IV and D-K specifications show the effect of quality treated as a continuous variable (with college quality normalized to have a mean of zero and a standard deviation of one to aid with interpreting the coefficients), while the B-S specification shows the effect of moving from the bottom-quartile to the top-quartile of the quality distribution (and should thus have coefficients roughly 2.4 times as large). For the IV and D-K methods, I use a probit specification to estimate the effects on “earned a bachelor's degree” and “attended or attending graduate school,” and report the marginal effect for a student with mean characteristics. Respondents who were enrolled in college in the year 2000 were excluded from the estimates of the effects on annual earnings and predicted future weekly wages, while those individuals who were enrolled or working less than full-time were excluded from the estimates of the effects on hourly earnings.[15, 16]

[15] In an early version of this paper, I found very little evidence of effects of college quality on working full-time.

[16] Roughly 24% of the sample would be lost due to having at least one missing control variable (***X***, ***F***, or ***N***). Thus, I impute the missing values of the control variables using the best available subset of the other control variables. The coefficient estimates are qualitatively similar (although estimated with less precision) when not including these imputations.

5a. Effect of Selectivity / Peer Quality

Table 4 contains the estimated effects of selectivity and peer quality, as measured by the college's median freshman SAT test score. All four specifications show a positive effect of selectivity/peer quality on earning a bachelor's degree. A one standard deviation (116 point) increase in peers' median SAT score would increase the likelihood of earning a bachelor's degree by 10.4 percentage points using the OLS (full sample) specification. The estimated effect in the IV specification is larger, while the estimated effect in the D-K specification is smaller and insignificant. Going from the bottom-quartile to the top-quartile of the college test score distribution would raise the likelihood of earning a bachelor's degree by 17.5 percentage points according to the B-S specification.[17] The effects on attending graduate school are similar, although smaller: 3 of the 4 specifications show positive significant effects, while the D-K specification shows a nearly zero effect. Using the OLS (full sample) specification, a one standard deviation increase in peers' median SAT score would increase the likelihood of attending graduate school by 3.7 percentage points.

The OLS, IV, and B-S specifications show positive effects of peer SAT test scores on all earnings measures (most of which are significant using the OLS and B-S methods), while the D-K

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[17] It should be remembered that these results are only the average effects and should be interpreted only as pertaining to the margin under which students and colleges are making these enrollment decisions. In other words, attending a much more selective college may not have positive effects on all students. Kane (1998), Bowen and Bok (1998), Melguizo (2003), and Alon and Tienda (forthcoming) find higher likelihoods of graduation for students who attend more selective colleges. Light and Strayer (2000) find negative effects on graduation probabilities for low ability students who attend more selective colleges, and positive effects for high ability students only up to a point.

specification finds negative, but insignificant, effects on all of the earnings measures. Using the OLS results, the effects are large: a one standard deviation increase in peers' median SAT score would raise annual earnings by over $3,000 for men and over $1,000 for women.

5b. Effect of Net Tuition

Table 5 contains the estimated effects of net tuition. By itself, net tuition cannot be seen as a pure quality of a college. However, if net tuition reflects demand for admission into the college, it would be correlated with the college's overall quality, ***Q***. Additionally, employers may believe that higher tuition signals higher college quality, and thus be willing to pay a premium to students from high tuition colleges, particularly when the student's own ability is difficult to observe. Net tuition is also interesting as Dale and Krueger found significant effects of net tuition on wages in their data.

The effects of net tuition on educational attainment are positive using the OLS, IV, and B-S specifications, but negative (insignificant) using the D-K method. A one standard deviation ($3,132) increase in net tuition would increase the likelihood of earning a bachelor's degree by 6.5 percentage points using the OLS (full sample) specification. The estimated effects on graduate school attendance are smaller and generally insignificant.

For male hourly and annual earnings, the estimated effects are positive using all of the specifications. Using the OLS (full sample) specification, a one standard deviation increase in net tuition would raise hourly earnings 0.043 log-points, and annual earnings $1,634. The effects using the IV and D-K specifications are of similar magnitude, but are insignificant due to higher standard errors. The B-S specification also shows positive effects: going from the bottom-quartile of the net tuition distribution to the top-quartile increases hourly earnings 0.117 log-points, and annual earnings $1,489. For female earnings, the effects are mixed sign and generally insignificant.

The effects of net tuition on predicted future wages are positive for both men and women using the OLS, IV, and B-S specifications, but negative using the D-K method. The effects are significant for men using the OLS and IV specifications; according to the OLS (full sample) specification, a one standard deviation in net tuition would lead to an increase in future weekly wages of $15 for men and $12 for women.

The effects on couples' annual earnings are positive but insignificant using all four specifications.

5c. Effect of Faculty Quality

Table 6 contains the estimated effects of faculty quality, as proxied by the college's average full professor salary, adjusted for cost of living. The effects on degree attainment are all insignificant.

For male earnings, the estimated effects are again mixed. The OLS and B-S estimates effects are positive and significant. However, the IV and D-K estimates are negative, but insignificant. For female earnings, the estimated effects are negative using the OLS and IV specifications, mixed-sign using the D-K method, and positive using the B-S method. Moreover, the IV estimates are significant (and perhaps implausible large). Thus, there is no clear pattern in the estimated results on actual earnings. The effects on predicted future wages are also mixed sign and generally insignificant. This result is not surprising as there were no significant effects on educational attainment.

On the other hand, the effects on couples' annual earnings are positive using all four specifications and significant in the OLS results. According to the OLS (full sample) specification, a one standard deviation increase in faculty salaries raises a couple's annual earnings by over $2,000.

5d. Effect of Faculty Availability

Table 7 contains the estimated effects of faculty availability, as proxied by the college's professor-student ratio. The clearest effect of faculty availability is for earning a bachelor's degree, where the effect is positive for all specifications and significant in the OLS, D-K, and B-S estimates. A one standard deviation (0.014) increase in the professor-student ratio would raise each student's likelihood of earning a bachelors degree by 9.0 percentage points according to the OLS (full sample) specification. The B-S specification shows significant effects of faculty availability on both bachelor's degree attainment and attending graduate school; going from the bottom-quartile of the faculty-student ratio distribution to the top-quartile would increase the likelihood of earning a bachelors degree by 13.6 percentage points and raise the likelihood of attending graduate school by 7.1 percentage points.

There is no evidence of an effect of faculty availability on men or women's actual or predicted earnings using any of the specifications. The results for predicted future earnings are surprising given the positive effects that are found for faculty availability on degree attainment.

For couple's annual earnings, the results are positive for all four specifications, and weakly significant for the OLS estimate. According to the OLS (full sample) specification, a one standard deviation increase in faculty availability would increase a couple's annual earnings by $2,790.

5e. Effect of Graduate Students' Share of Enrollment

Table 8 contains the estimated effects of the college's graduate student share of enrollment. While the IV estimates are included here, it should be remembered that the instrumental variable was not significant in the first-stage.

The estimated effects of graduate students' share on educational attainment are positive in each specification. A one standard deviation (0.139) increase in graduate students' share of enrollment would raise a student's likelihood of earning a bachelors degree by 4.1 percentage points according to the OLS (full sample) specification. Likewise, going from the bottom-quartile to the top-quartile in the distribution of colleges would raise the likelihood of earning a bachelors degree by 5.1 percentage points and raise the likelihood of attending graduate school by 7.2 percentage points according to the B-S specification. These estimated effects are significant. The estimated effects using the IV and D-K specifications are insignificant.

The effects of graduate students' share on male and female earnings are positive and usually significant using the OLS, D-K, and B-S methods. Using to the OLS (full sample) specification, a one standard deviation increase in graduate students' share of enrollment would raise hourly earnings by 0.075 and 0.045 log-points and annual earnings $2,068 and $579 for men and women, respectively. The effects on predicted future weekly earnings are also positive using all specifications for both men and women.

For couple's annual earnings, the results are positive for all four specifications, and significant in the OLS estimates. According to the OLS (full sample) specification, a one standard deviation increase in graduate student's share of enrollment would increase a couple's annual earnings by $3,171.

5f. Effect of Overall College Quality

Table 9 shows the results for the index of college quality based on the first principal component of the above five measures of college quality.

The strongest evidence for a positive effect of college quality is shown by the consistently estimated positive effects on educational attainment – most of which are significant and large. A one standard deviation increase in overall college quality raises the likelihood of earning a bachelor's degree by 10.5 percentage points and raises the likelihood of attending graduate school 2.9 percentage points according to the OLS (full sample) specification. The IV and D-K estimates are all positive, but mostly insignificant. The B-S estimates of the effect of quality on educational attainment are positive, significant, and large: moving from the bottom-quartile to the top-quartile in the overall college quality index raises the likelihoods of earning a bachelors degree and attending graduate school by 19.1 and 13.5 percentage points, respectively.

The effects of overall quality on male earnings are likewise consistently positive. For both hourly and annual earnings, the OLS and B-S estimates are positive and significant, while the IV and D-K estimates are positive but insignificant. The positive, significant effects on hourly earnings found using the B-S specification (0.211, s.e. = 0.066) are somewhat similar to the Black and Smith (2004) results, despite using a different dataset and different quality measures in the college quality index. For male earnings, they found a 0.159 (s.e. = 0.058) effect on male log wages using OLS, and 0.139 (s.e. = 0.077) effect using their propensity score matching technique.

The effects of overall quality on female earnings are generally insignificant. Again, my results are consistent with the results in Black and Smith (2004), albeit with smaller point estimates. Using the B-S specification, I find that moving from the bottom-quartile to the top-quartile of the college quality distribution raises female hourly earnings 0.059 log points (s.e. = 0.050) using the OLS specification, but only 0.020 (s.e. = 0.066) using the B-S specification. Black and Smith report the following estimates: 0.155 (s.e. = 0.055) using OLS, and 0.078 (s.e. = 0.083) using their propensity score matching technique.

Given the strong positive effects of overall quality on educational attainment, it would be reasonable to expect comparable positive effects on predicted future earnings. This prediction holds true for all four specifications, where the effects are all positive and mostly significant. According to the OLS (full sample) specification, a one standard deviation increase in overall college quality would increase future weekly earnings by $24 for men and $33 for women.

For couple's annual earnings, the results are positive for all four specifications, and significant in the OLS and B-S estimates. According to the OLS (full sample) specification, a one standard deviation increase in overall college quality would increase a couple's annual earnings by $5,424.

Looking back through the results shown in Tables 4-9, the effects of college quality on early adult outcomes generally show positive effects, particularly for educational attainment. The strongest evidence for positive effects of college quality on educational attainment is found in the effects of selectivity, faculty availability, graduate students' share of enrollment, and the overall quality index. For actual earnings, the strongest evidence is found in the effects of graduate students' share of enrollment and the overall quality index, particularly for males. These same measures of college quality have clear positive effects on predicted future earnings. For couples' earnings, the strongest evidence for positive effects is through the college's full professors' salaries, graduate students' share of enrollment, and the overall quality index. While not every measure of college quality has clear positive effects on each of the students' later life outcomes, the overall pattern shows unambiguous evidence that college quality does matter.

6. Conclusion

This paper has evaluated the effects of six different college qualities on the early adult outcomes of college enrollees, using four different specifications. A few general themes emerge. First, ordinary least squares estimates appear to show that a variety of different college qualities have positive effects on students’ labor market and educational outcomes. While such estimates could suffer from omitted variable bias due to selection of college quality based on unobserved student characteristics, alternative estimation methods find only modest evidence for such bias. Second, several college qualities have positive effects on educational attainment when estimated with a variety of specifications. This result is important, as many studies focus too narrowly on particular inputs and outcomes, and may miss the effects of college quality. Third, the estimated effects on wages are mixed. While the OLS estimates tend to find positive significant effects in many cases, the alternative methods do not consistently find such positive effects. As the individuals studied here are young adults, the effects on wages may yet occur in later life. There is some evidence for positive effects of college quality on predicted future earnings, given the young adults' current occupation and education levels.

The findings here – that certain college qualities have effects on specific outcomes, while others do not – suggest that the education production function is quite complicated. That is, there is no such thing as a single index of quality that uniformly affects all possible outcomes. This research demonstrates the importance of viewing school quality as multi-faceted with a broad array of possible effects. Further work should explore non-linearities and interactions in the effects of college qualities. Furthermore, additional work should be done exploring the interaction of college qualities with student attributes to explore whether quality has differential effects on sub-groups in the population.

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Table 1

Descriptive Statistics

	Variable	NELS students who enrolled in a 4-year college by 1994: Number of Non-Missing Observations	Mean*	Standard Deviation*	Minimum	Maximum	Remaining NELS Students: Mean*
Outcomes (LHS)	Earned a Bachelor's Degree	4,899	0.66	0.47	0	1	0.07
	Attended or Attending Graduate School	4,864	0.24	0.42	0	1	0.02
	Hourly Earnings (For Those Not Enrolled and Working Full-Time) -- Men	1,383	17.32	10.23	1.19	192.31	14.31
	Hourly Earnings (For Those Not Enrolled and Working Full-Time) -- Women	1,462	14.45	5.69	0.00	54.95	10.87
	Annual Earnings (For Those Not Enrolled) -- Men	1,509	36,225	24,182	0	413,445	29,988
	Annual Earnings (For Those Not Enrolled) -- Women	1,773	26,953	14,554	0	206,723	16,505
	Predicted Weekly Earnings at Age 40 (For Those Not Enrolled) -- Men	1,587	1,018	236	462	1,697	721
	Predicted Weekly Earnings at Age 40 (For Those Not Enrolled) -- Women	1,871	705	208	256	1,356	454
	Self + Spouse's Annual Earnings (For Those Not Enrolled and With Spouse/Partner)	2,013	59,983	34,375	0	537,479	48,984
College Qualities (RHS)	Median Freshman SAT Score	4,938	979	116	660	1,379	
	Average Net Tuition	4,869	2,406	3,132	-12,182	14,822	
	Adjusted Full Professor Salary	4,794	58,112	12,057	11,224	97,011	
	Professor - Student Ratio	4,841	0.039	0.014	0.008	0.130	
	Percentage of Students Who Are Graduate Students	4,929	0.178	0.139	0.000	0.760	
	Index of College Quality	4,749	-0.02	1.04	-2.53	4.24	
Other Control Variables	Age	4,856	25.7	0.5	20.0	29.3	26.0
	Female	4,938	0.53	0.50	0	1	0.48
	Hispanic	4,938	0.06	0.24	0	1	0.14
	Black	4,938	0.11	0.32	0	1	0.13
	Asian American	4,938	0.05	0.22	0	1	0.03
	High School GPA (Core Courses)	4,936	2.35	1.18	0.00	4.00	1.46
	Predicted SAT Score	4,911	940	186	400	1,530	698
	Father's Years of Education	4,634	14.8	2.8	8	20	12.4
	Mother's Years of Education	4,724	14.0	2.3	8	20	12.2
	Either Parent Earned a Bachelor's Degree	4,766	0.58	0.49	0	1	0.22
	Parents Married in 1988	4,471	0.86	0.35	0	1	0.75
	Parents' Income in 1991	4,318	59,671	46,338	0	242,947	34,585
	Number of Siblings in 1988 (8th Grade)	4,515	1.95	1.37	0	6	2.47
	Family is Catholic	4,888	0.33	0.47	0	1	0.32
	Family is Protestant (and other non-Catholic Christian)	4,888	0.56	0.50	0	1	0.57
	Family is Other Religion	4,888	0.08	0.27	0	1	0.06
	Home Language is Not Primarily English in 1988	4,791	0.08	0.27	0	1	0.13
	Percent of Adults (Age 25+) in the Student's Zip Code Who Have a Bachelor's Degree	4,869	0.23	0.14	0.00	0.76	0.16
	Percent of Adults (Age 25+) in the Student's Zip Code Who Have a Graduate Degree	4,869	0.08	0.07	0.00	0.46	0.06
	Unemployment Rate in the Student's Zip Code	4,869	0.06	0.04	0.00	0.42	0.08
	Income per capita in the Student's Zip Code	4,869	15,344	7,177	1,516	82,506	12,706
	Urban High School	4,934	0.30	0.46	0	1	0.29
	Rural High School	4,934	0.27	0.45	0	1	0.33
	High School Quality Index	4,845	0.34	1.05	-2.96	4.01	-0.23

* Weighted by the NELS variable "f4f2pnwt," which scales the 2000 sample of respondents to the 1992 population of high school seniors and accounts for the initial sampling scheme and non-response.

Table 2
Descriptive Statistics for Top and Bottom Quartile Colleges

	Top Quartile ("Treated")		Bottom Quartile ("Untreated")		
	N	**Mean***	**N**	**Mean***	**Difference in Means**
Median Freshman SAT Score	1,528	1,130	1,140	856	275
Fraction of Students Who Are Graduate Students	983	0.391	1,493	0.033	0.358
Adjusted Full Professor Salary	1,260	73,941	1,199	43,974	29,967
Professor - Student Ratio	1,627	0.054	746	0.023	0.031
Average Net Tuition	1,435	7,427	1,055	732	6,696
Index of College Quality	1,356	1.38	1,156	-1.05	2.43

Source: NELS students who enrolled in a 4-year college by 1994.
* Weighted by "f4f2pnwt" (see text).

Table 3a
Summary of the Effects of College Quality

Significance of the Coefficients (two-tailed, 10% level)

		OLS (Full Sample)	OLS (D-K Sample)	OLS (B-S Sample)	IV (Full Sample)	Dale and Krueger Method	Black and Smith Method
Earned a Bachelor's Degree	Positive and Significant	5	0	5	2	1	5
	Positive but Insignificant	1	4	1	3	3	1
	Negative but Insignificant	0	1	0	1	2	0
	Negative and Significant	0	1	0	0	0	0
Attended or Attending Graduate School	Positive and Significant	3	0	5	1	0	4
	Positive but Insignificant	3	5	0	3	4	2
	Negative but Insignificant	0	1	1	2	2	0
	Negative and Significant	0	0	0	0	0	0
Log Hourly Earnings -- Men	Positive and Significant	5	2	4	0	1	5
	Positive but Insignificant	1	4	1	3	3	0
	Negative but Insignificant	0	0	1	3	2	1
	Negative and Significant	0	0	0	0	0	0
Annual Earnings -- Men	Positive and Significant	5	4	4	0	1	4
	Positive but Insignificant	1	2	2	4	3	2
	Negative but Insignificant	0	0	0	2	2	0
	Negative and Significant	0	0	0	0	0	0
Log Hourly Earnings -- Women	Positive and Significant	1	1	3	0	0	1
	Positive but Insignificant	3	3	3	3	2	4
	Negative but Insignificant	2	2	0	2	4	1
	Negative and Significant	0	0	0	1	0	0
Annual Earnings -- Women	Positive and Significant	1	2	1	1	0	2
	Positive but Insignificant	4	3	4	2	3	3
	Negative but Insignificant	1	1	1	2	3	1
	Negative and Significant	0	0	0	1	0	0
Predicted Weekly Earnings -- Men	Positive and Significant	3	3	3	4	1	4
	Positive but Insignificant	3	2	3	0	1	2
	Negative but Insignificant	0	1	0	2	4	0
	Negative and Significant	0	0	0	0	0	0
Predicted Weekly Earnings -- Women	Positive and Significant	4	4	4	1	0	4
	Positive but Insignificant	2	2	2	3	4	2
	Negative but Insignificant	0	0	0	2	2	0
	Negative and Significant	0	0	0	0	0	0
Self + Spouse's Annual Earnings	Positive and Significant	5	4	2	0	0	2
	Positive but Insignificant	1	2	4	6	5	4
	Negative but Insignificant	0	0	0	0	1	0
	Negative and Significant	0	0	0	0	0	0
Total	Positive and Significant	32	20	31	9	4	31
	Positive but Insignificant	19	27	20	27	28	20
	Negative but Insignificant	3	6	3	16	22	3
	Negative and Significant	0	1	0	2	0	0

Table 3b
Summary of the Effects of College Quality -- Continued

Significance of the difference with the OLS Coefficients Using the Same Sample (two-tailed, 10% level)

		IV (Full Sample)	Dale and Krueger Method	Black and Smith Method
Earned a Bachelor's Degree	Significantly > than OLS	0	0	0
	Insignificantly different than OLS	6	6	5
	Significantly < than OLS	0	0	1
Attended or Attending Graduate School	Significantly > than OLS	1	0	0
	Insignificantly different than OLS	5	5	6
	Significantly < than OLS	0	1	0
Log Hourly Earnings -- Men	Significantly > than OLS	0	0	1
	Insignificantly different than OLS	6	5	5
	Significantly < than OLS	0	1	0
Annual Earnings -- Men	Significantly > than OLS	0	0	0
	Insignificantly different than OLS	6	6	6
	Significantly < than OLS	0	0	0
Log Hourly Earnings -- Women	Significantly > than OLS	0	0	0
	Insignificantly different than OLS	5	6	6
	Significantly < than OLS	1	0	0
Annual Earnings -- Women	Significantly > than OLS	0	0	0
	Insignificantly different than OLS	5	5	6
	Significantly < than OLS	1	1	0
Predicted Weekly Earnings -- Men	Significantly > than OLS	4	0	1
	Insignificantly different than OLS	2	5	5
	Significantly < than OLS	0	1	0
Predicted Weekly Earnings -- Women	Significantly > than OLS	0	0	0
	Insignificantly different than OLS	6	6	6
	Significantly < than OLS	0	0	0
Self + Spouse's Annual Earnings	Significantly > than OLS	0	0	0
	Insignificantly different than OLS	6	6	6
	Significantly < than OLS	0	0	0
Total	Significantly > than OLS	5	0	2
	Insignificantly different than OLS	47	50	51
	Significantly < than OLS	2	4	1

Source: NELS students who enrolled in a 4-year college by 1994.

Table 4
Effect of Selectivity / Peer Quality

College Quality = Median Freshman SAT / ACT Score

	1 Standard Deviation (116 Point) Increase				*Bottom to Top Quartile*	
	OLS (Full Sample)	IV (Full Sample)	OLS (D-K Sample)	Dale and Krueger Method	OLS (B-S Sample)	Black and Smith Method
Earned a Bachelor's Degree	0.104 *** (0.016) N = 4,899	0.218 ** (0.090) N = 4,895	0.053 (0.035) N = 1,505	0.025 (0.054) N = 1,505	0.186 *** (0.037) N = 2,648	0.175 *** (0.039) N = 2,648 B = 0.05
Attended or Attending Graduate School	0.037 *** (0.012) N = 4,864	0.144 ** (0.064) + N = 4,860	0.029 (0.023) N = 1,685	-0.001 (0.037) N = 1,685	0.088 *** (0.031) N = 2,631	0.091 ** (0.041) N = 2,631 B = 0.15
Log Hourly Earnings -- Men	0.021 *** (0.021) N = 1,383	0.259 (0.163) N = 1,383	0.053 (0.033) N = 603	-0.128 (0.109) - N = 603	0.224 *** (0.056) N = 722	0.193 *** (0.060) N = 722 B = 0.15
Annual Earnings -- Men	3,022 *** (986) N = 1,509	7,536 (5,573) N = 1,509	4,414 *** (1,532) N = 657	-6,598 (4,976) -- N = 657	7,361 ** (3,007) N = 796	9,780 *** (2,703) N = 796 B = 0.10
Log Hourly Earnings -- Women	0.033 (0.021) N = 1,462	0.179 (0.131) N = 1,461	0.015 (0.028) N = 685	-0.132 (0.131) N = 685	0.091 (0.060) N = 754	0.075 (0.071) N = 754 B = 0.20
Annual Earnings -- Women	1,131 ** (515) N = 1,773	6,239 * (3,228) N = 1,771	1,331 * (766) N = 802	-3,131 (2,229) -- N = 802	2,165 * (1,312) N = 923	889 (2,490) N = 923 B = 0.05
Predicted Weekly Earnings -- Men	28 *** (9) N = 1,587	177 *** (62) +++ N = 1,587	32 ** (16) N = 693	-60 (53) - N = 693	92 *** (25) N = 834	135 *** (32) N = 834 B = 0.20
Predicted Weekly Earnings -- Women	31 *** (10) N = 1,871	70 (49) N = 1,869	21 (15) N = 848	-13 (27) N = 848	85 *** (21) N = 987	76 * (42) N = 987 B = 0.10
Self + Spouse's Annual Earnings	3,727 *** (1,394) N = 1,498	4,298 (8,184) N = 1,496	5,844 *** (1,849) N = 620	-909 (5,028) N = 620	6,720 * (3,569) N = 725	8,868 ** (3,917) N = 725 B = 0.20

Source: NELS students who enrolled in a 4-year college by 1994.

"***", "**", and "*" indicated two-tailed significance at the 1%, 5%, and 10% levels.
"+++" ("---") indicates significantly higher (lower) than the OLS specification.

Each parameter estimate comes from a separate specification. Standard errors are below the parameter estimates in parentheses. Respondents enrolled in college or working less than full-time were excluded in estimating the effect on log hourly earnings, while respondents enrolled in college were excluded in estimating the effect on annual earnings. All specifications are weighted using "f4f2pnwt."

For the OLS, IV, and Dale and Krueger specifications, regressions also include age, age-squared, female, black, Hispanic, Asian American, core grade point average, predicted SAT test score, father's and mother's years of education, parent earned a bachelor's degree, parents married, parents' income, income-squared, number of siblings, Catholic, other Christian, other religion, non-English speaking household, percent of adults in the student's zip code who have a bachelor's degree, percent of adults in the student's zip code who have a graduate degree, unemployment in the student's zip code, income per capita in the student's zip code, urban high school, rural high school, and an index of high school quality.

Standard errors for the Black and Smith Method are found by bootstrapping the estimates 500 times.

Table 5
Effect of Net Tuition

College Quality = Average Net Tuition

	1 Standard Deviation ($3,132) Increase				*Bottom to Top Quartile*	
	OLS (Full Sample)	IV (Full Sample)	OLS (D-K Sample)	Dale and Krueger Method	OLS (B-S Sample)	Black and Smith Method
Earned a Bachelor's Degree	0.065 *** (0.015) N = 4,832	0.047 (0.036) N = 4,832	-0.080 ** (0.031) N = 1,692	-0.023 (0.048) N = 1,692	0.106 *** (0.031) N = 2,568	0.050 * (0.027) -- N = 2,568 B = 0.10
Attended or Attending Graduate School	0.011 (0.010) N = 4,797	0.018 (0.027) N = 4,797	0.008 (0.019) N = 1,769	-0.010 (0.035) N = 1,769	0.053 * (0.030) N = 2,555	0.012 (0.031) N = 2,555 B = 0.20
Log Hourly Earnings -- Men	0.043 ** (0.018) N = 1,369	0.013 (0.059) N = 1,369	0.056 (0.038) N = 606	0.042 (0.115) N = 606	0.018 (0.051) N = 724	0.117 ** (0.056) + N = 724 B = 0.10
Annual Earnings -- Men	1,634 * (881) N = 1,494	856 (2,300) N = 1,494	2,352 (1,985) N = 655	1,517 (8,732) N = 655	490 (2,506) N = 780	1,489 (3,620) N = 780 B = 0.15
Log Hourly Earnings -- Women	0.001 (0.023) N = 1,444	0.037 (0.066) N = 1,444	0.026 (0.023) N = 691	0.019 (0.090) N = 691	0.096 * (0.055) N = 775	0.032 (0.051) N = 775 B = 0.20
Annual Earnings -- Women	493 (534) N = 1,749	606 (1,409) N = 1,749	-133 (760) N = 815	-1,297 (2,142) N = 815	1,958 (1,415) N = 929	-517 (1,742) N = 929 B = 0.15
Predicted Weekly Earnings -- Men	15 ** (7) N = 1,571	62 *** (23) ++ N = 1,571	-2 (14) N = 693	-55 (46) N = 693	31 *** (20) N = 825	30 (27) N = 786 B = 0.15
Predicted Weekly Earnings -- Women	12 (8) N = 1,846	20 (21) N = 1,846	13 *** (11) N = 857	-17 (24) N = 857	45 ** (19) N = 980	22 (23) N = 916 B = 0.30
Self + Spouse's Annual Earnings	2,244 (1,572) N = 1,482	1,493 (3,588) N = 1,482	3,207 (2,520) N = 652	6,944 (12,046) N = 652	4,964 (3,575) N = 740	3,154 (4,238) N = 728 B = 0.20

Source: NELS students who enrolled in a 4-year college by 1994.

"***", "**", and "*" indicated two-tailed significance at the 1%, 5%, and 10% levels.
"+++" ("---") indicates significantly higher (lower) than the OLS specification.

See notes to Table 4.

Table 6
Effect of Effect of Faculty Quality

College Quality = Adjusted Full Professor Salary

	1 Standard Deviation ($12,057) Increase				*Bottom to Top Quartile*	
	OLS (Full Sample)	IV (Full Sample)	OLS (D-K Sample)	Dale and Krueger Method	OLS (B-S Sample)	Black and Smith Method
Earned a Bachelor's Degree	0.018 (0.012) N = 4,758	-0.012 (0.081) N = 4,758	0.012 (0.026) N = 1,465	-0.030 (0.040) N = 1,465	0.029 (0.029) N = 2,444	0.033 (0.025) N = 2,444 B = 0.05
Attended or Attending Graduate School	0.002 (0.009) N = 4,724	-0.048 (0.055) N = 4,724	-0.030 (0.021) N = 1,602	0.024 (0.039) N = 1,602	-0.001 (0.024) N = 2,421	0.003 (0.030) N = 2,421 B = 0.20
Log Hourly Earnings -- Men	0.045 *** (0.018) N = 1,346	-0.143 (0.144) N = 1,346	0.066 (0.041) N = 576	-0.083 (0.099) N = 576	0.124 ** (0.051) N = 703	0.152 *** (0.055) N = 703 B = 0.25
Annual Earnings -- Men	1,947 ** (785) N = 1,469	-333 (5,799) N = 1,469	3,936 ** (1,640) N = 619	-3,781 (7,133) N = 619	4,084 * (2,108) N = 754	6,777 *** (2,339) N = 754 B = 0.40
Log Hourly Earnings -- Women	-0.007 (0.015) N = 1,411	-0.299 *** (0.104) --- N = 1,411	0.036 (0.025) N = 652	-0.090 (0.102) N = 652	0.052 (0.043) N = 720	0.054 (0.048) N = 720 B = 0.35
Annual Earnings -- Women	-250 (440) N = 1,712	-8,695 *** (2,944) --- N = 1,712	1,419 ** (680) N = 763	280 (1,995) N = 763	81 (1,415) N = 868	1,872 (1,664) N = 868 B = 0.20
Predicted Weekly Earnings -- Men	5 (8) N = 1,545	-45 (61) N = 1,545	23 (17) N = 649	-1 (46) N = 649	34 (22) N = 794	59 ** (26) N = 794 B = 0.25
Predicted Weekly Earnings -- Women	8 (7) N = 1,807	-48 (39) N = 1,807	24 ** (11) N = 799	8 (28) N = 799	30 (20) N = 913	38 * (21) N = 913 B = 0.20
Self + Spouse's Annual Earnings	2,109 ** (1,020) N = 1,449	3,944 (6,051) N = 1,449	3,776 ** (1,703) N = 577	744 (6,900) N = 577	2,429 (3,393) N = 733	5,656 (3,602) N = 733 B = 0.10

Source: NELS students who enrolled in a 4-year college by 1994.

"***", "**", and "*" indicated two-tailed significance at the 1%, 5%, and 10% levels.
"+++" ("---") indicates significantly higher (lower) than the OLS specification.

See notes to Table 4.

Table 7
Effect of Faculty Availability

College Quality = Professor - Student Ratio

	1 Standard Deviation (0.014) Increase				*Bottom to Top Quartile*	
	OLS (Full Sample)	IV (Full Sample)	OLS (D-K Sample)	Dale and Krueger Method	OLS (B-S Sample)	Black and Smith Method
Earned a Bachelor's Degree	0.090 *** (0.016) N = 4,803	0.060 (0.146) N = 4,803	0.029 (0.031) N = 1,780	0.091 ** (0.039) N = 1,780	0.188 *** (0.041) N = 2,354	0.136 *** (0.033) N = 2,354 B = 0.20
Attended or Attending Graduate School	0.019 * (0.011) N = 4,769	-0.018 (0.089) N = 4,769	0.026 (0.021) N = 1,915	0.037 (0.035) N = 1,915	0.087 *** (0.030) N = 2,339	0.071 ** (0.035) N = 2,339 B = 0.15
Log Hourly Earnings -- Men	0.018 (0.021) N = 1,357	-0.408 (0.284) N = 1,357	0.016 (0.042) N = 643	0.021 (0.075) N = 643	-0.039 (0.054) N = 650	-0.022 (0.055) N = 650 B = 0.15
Annual Earnings -- Men	469 (743) N = 1,482	-7,155 (10,782) N = 1,482	1,545 (1,459) N = 698	298 (4,947) N = 698	574 (2,101) N = 713	1,240 (2,725) N = 713 B = 0.20
Log Hourly Earnings -- Women	-0.016 (0.029) N = 1,426	-0.032 (0.151) N = 1,426	-0.031 (0.023) N = 725	-0.118 (0.111) N = 725	0.014 (0.097) N = 685	-0.006 (0.059) N = 685 B = 0.65
Annual Earnings -- Women	90 (559) N = 1,728	-3,773 (4,728) N = 1,728	360 (698) N = 858	-1,169 (1,545) N = 858	-480 (1,464) N = 837	938 (1,638) N = 837 B = 0.20
Predicted Weekly Earnings -- Men	12 (8) N = 1,560	-19 (108) N = 1,560	21 (15) N = 736	-5 (29) N = 736	35 (27) N = 746	29 (28) N = 746 B = 0.15
Predicted Weekly Earnings -- Women	17 * (10) N = 1,824	-49 (59) N = 1,824	20 (12) N = 901	10 (25) N = 901	49 (30) N = 876	13 (30) N = 876 B = 0.15
Self + Spouse's Annual Earnings	2,790 * (1,530) N = 1,462	14,142 (9,684) N = 1,462	2,365 (1,666) N = 673	6,857 (5,181) N = 673	2,913 (3,039) N = 667	5,397 (3,514) N = 667 B = 0.55

Source: NELS students who enrolled in a 4-year college by 1994.

"***", "**", and "*" indicated two-tailed significance at the 1%, 5%, and 10% levels.
"+++" ("---") indicates significantly higher (lower) than the OLS specification.

See notes to Table 4.

Table 8
Effect of Graduate Students' Share of Enrollment

College Quality = Fraction of Students Who Are Graduate Students

	1 Standard Deviation (0.139) Increase				*Bottom to Top Quartile*	
	OLS (Full Sample)	IV (Full Sample)	OLS (D-K Sample)	Dale and Krueger Method	OLS (B-S Sample)	Black and Smith Method
Earned a Bachelor's Degree	0.041 ***	0.379	0.037	0.049	0.092 ***	0.051 **
	(0.014)	(0.363)	(0.030)	(0.046)	(0.033)	(0.025)
	N = 4,891	N = 4,891	N = 1,081	N = 1,081	N = 2,456	N = 2,456
						B = 0.05
Attended or Attending Graduate School	0.012	0.430	0.010	0.026	0.069 **	0.072 ***
	(0.010)	(0.265)	(0.023)	(0.038)	(0.030)	(0.030)
	N = 4,856	N = 4,856	N = 1,247	N = 1,247	N = 2,441	N = 2,441
						B = 0.10
Log Hourly Earnings -- Men	0.075 ***	-0.035	0.096 ***	0.199 **	0.183 ***	0.154 ***
	(0.019)	(0.609)	(0.028)	(0.097)	(0.056)	(0.058)
	N = 1,382	N = 1,382	N = 458	N = 458	N = 669	N = 669
						B = 0.10
Annual Earnings -- Men	2,068 **	3,184	4,618 **	11,824 **	6,351 **	4,230
	(985)	(24,590)	(1,848)	(5,386)	(2,770)	(3,110)
	N = 1,507	N = 1,507	N = 487	N = 487	N = 734	N = 734
						B = 0.20
Log Hourly Earnings -- Women	0.045 ***	-0.159	0.082 ***	0.170	0.127 ***	0.123 ***
	(0.013)	(0.528)	(0.030)	(0.165)	(0.038)	(0.037)
	N = 1,459	N = 1,459	N = 482	N = 482	N = 760	N = 760
						B = 0.15
Annual Earnings -- Women	579	-6,141	1,519	740	1,583	2,968 **
	(497)	(14,055)	(961)	(2,274)	(1,346)	(1,445)
	N = 1,768	N = 1,768	N = 561	N = 561	N = 909	N = 909
						B = 0.85
Predicted Weekly Earnings -- Men	11	485 **	52 ***	42	32	42 *
	(7)	(246) +	(14)	(43)	(20)	(23)
	N = 1,585	N = 1,585	N = 511	N = 511	N = 777	N = 777
						B = 0.20
Predicted Weekly Earnings -- Women	23 ***	236	34 ***	11	71 ***	51 ***
	(8)	(230)	(13)	(33)	(21)	(21)
	N = 1,866	N = 1,866	N = 588	N = 588	N = 963	N = 963
						B = 0.10
Self + Spouse's Annual Earnings	3,171 **	21,211	4,285 *	8,399	3,301	6,191
	(1,577)	(31,215)	(2,299)	(5,913)	(3,661)	(4,239)
	N = 1,493	N = 1,493	N = 425	N = 425	N = 717	N = 717
						B = 0.15

Source: NELS students who enrolled in a 4-year college by 1994.

"***", "**", and "*" indicated two-tailed significance at the 1%, 5%, and 10% levels.
"+++" ("---") indicates significantly higher (lower) than the OLS specification.

See notes to Table 4.

Table 9
Effect of Overall College Quality

College Quality = Index of College Quality

	1 Standard Deviation Increase				*Bottom to Top Quartile*	
	OLS (Full Sample)	IV (Full Sample)	OLS (D-K Sample)	Dale and Krueger Method	OLS (B-S Sample)	Black and Smith Method
Earned a Bachelor's Degree	0.105 ***	0.175 **	-0.020	0.033	0.172 ***	0.191 ***
	(0.018)	(0.072)	(0.030)	(0.048)	(0.038)	(0.046)
	N = 4,713	N = 4,709	N = 1,417	N = 1,417	N = 2,508	N = 2,508
						B = 0.10
Attended or Attending Graduate School	0.029 **	0.088	0.026	0.030	0.116 ***	0.135 ***
	(0.013)	(0.057)	(0.024)	(0.044)	(0.034)	(0.041)
	N = 4,679	N = 4,675	N = 1,604	N = 1,604	N = 2,489	N = 2,489
						B = 0.10
Log Hourly Earnings -- Men	0.095 ***	0.060	0.101 ***	0.027	0.180 ***	0.211 ***
	(0.021)	(0.138)	(0.038)	(0.113)	(0.054)	(0.066)
	N = 1,336	N = 1,336	N = 575	N = 575	N = 717	N = 717
						B = 0.20
Annual Earnings -- Men	3,064 ***	2,937	4,990 ***	78	7,218 ***	9,409 ***
	(1,043)	(4,763)	(1,729)	(5,974)	(2,899)	(2,914)
	N = 1,459	N = 1,459	N = 624	N = 624	N = 782	N = 782
						B = 0.20
Log Hourly Earnings -- Women	0.021	0.161	-0.017	-0.073	0.059 **	0.020
	(0.024)	(0.122)	(0.036)	(0.122)	(0.050)	(0.066)
	N = 1,399	N = 1,398	N = 640	N = 640	N = 703	N = 703
						B = 0.10
Annual Earnings -- Women	816	2,150	359	1,743	414	3,799 *
	(633)	(2,821)	(798)	(2,802)	(1,587)	(2,135)
	N = 1,697	N = 1,695	N = 756	N = 756	N = 874	N = 874
						B = 0.15
Predicted Weekly Earnings -- Men	24 ***	122 **	47 ***	93 *	83 ***	150 ***
	(9)	(53) +	(15)	(53)	(26)	(36) +
	N = 1,534	N = 1,534	N = 656	N = 656	N = 821	N = 821
						B = 0.15
Predicted Weekly Earnings -- Women	33 ***	73 *	34 ***	22	57 ***	93 **
	(10)	(40)	(12)	(32)	(22)	(41)
	N = 1,791	N = 1,789	N = 796	N = 796	N = 919	N = 919
						B = 0.15
Self + Spouse's Annual Earnings	5,424 ***	2,818	5,409 **	4,710	7,478 **	11,168 ***
	(1,756)	(6,895)	(2,347)	(6,476)	(3,703)	(4,638)
	N = 1,439	N = 1,437	N = 580	N = 580	N = 720	N = 720
						B = 0.10

Source: NELS students who enrolled in a 4-year college by 1994.

"***", "**", and "*" indicated two-tailed significance at the 1%, 5%, and 10% levels.
"+++" ("---") indicates significantly higher (lower) than the OLS specification.

See notes to Table 4.

8. Appendix

8a. Notes on the Data

Outcomes

- Regarding the computation of hourly earnings: Survey respondents were asked their rate of pay and pay period. For those non-hourly workers (i.e., those whose rate of pay was based on weekly, bi-weekly, monthly, or annual periods), I estimate an hourly wage using their reported hours worked in a typical week. For this calculation, I used 52 weeks for annual salaries, 4.33 weeks (i.e., 52/12) for monthly salaries, and 2.08 weeks (i.e., the average of 52/24 and 2) for persons with bi-weekly or twice per month salaries.

College Qualities

- Regarding the computation of the college's median freshman SAT test score: For colleges reporting ACT scores, these scores are converted into SAT-equivalent scores and then averaged with the SAT scores, when both are available. For some colleges, I estimate medians by the fraction of students who are within categorical ranges (e.g., percentage with ACT score less than 21, 21 to 23, etc.). For this calculation, I multiply the percentages in each categorical range by an estimate of the average score of students in this range. These estimates are based on the SAT test score distribution for the 1991-92 school year, as reported in the 1995 Digest of Education Statistics (Table 126), and the ACT test score distribution as reported by ACT, Inc. in the "ACT 1992 National High School Profile Report." For a small number of colleges, I assign the average SAT score of schools in their Barron's selectivity tier when test score data are not reported.
- Regarding the computation of the college's net tuition: List tuition and total financial aid data were taken from American Universities and Colleges (1992). In-state tuition was used

for universities that listed both in-state and out-of-state tuitions. Total undergraduate enrollment was taken from IPEDS.

- Regarding the computation of the college's average full professor's salary adjusted for the local cost of living: Average professors' salary equals the sum of salaries paid to full professors divided by the total number of full professors. Salaries are adjusted for local cost of living based on variation in cost of living by state and urban/suburban/rural location. This adjustment is done in two stages. First, I compute the average 1989 salary of persons with a master's degree or higher who usually worked 35 or more hours per week by state, using data from a 5% sample of the 1990 Decennial Census. This average salary ranged from $29,192 in South Dakota to $54,218 in the District of Columbia. I create a state cost-of-living multiplier by dividing this value by $43,074, which was the national average 1989 salary of persons with a master's degree or higher who usually worked 35 or more hours per week. I then divide the college's average faculty salary by the state cost-of-living multiplier. Second, I divide this ratio by a multiplier for urban, suburban, and rural areas. The urbanacity multiplier is derived by averaging the state-adjusted average full professor salary for urban, suburban, and rural counties. I define a county as urban if it contains the central business district of a Metropolitan Statistical Area (MSA). I define a county as suburban if it contains any part of an MSA, but does not contain the central business district. I define all other counties as rural. Since state differences are already included, this urbanacity multiplier has small effects – it equals 1.022 for urban counties, 0.978 for suburban counties, and 0.964 for rural counties.
- Regarding the computation of the college's professors per student: Professors per student equals the total number of professors divided by all enrolled students. This measure is not

adjusted for full- versus part-time professors or students. One college had a professor-student ratio equal to 30 – this value was set to missing as it was clearly due to faulty data.

Control Variables

- Predicted SAT test score is based on actual SAT and ACT-equivalent test scores when available, or else based on NELS administered tests in math, reading, history, and social studies given in the 8^{th}, 10^{th}, and 12^{th} grades.
- Neighborhood characteristics are based on the zip code of the student's school district using data from the 1990 Census.
- Parents' 1991 income was reported in 15 categorical ranges, with the top-range including incomes above $200,000. For each categorical range, I estimated an average income using a 1% sample of the 1990 Census housing records. From this Census data, I restricted the sample to those families who had a child present who was under 18, and then computed the average family income for each NELS income range.
- The index of high school quality is based on five school qualities measured in both the 10^{th} and 12^{th} grades: district instructional and support expenditures per pupil, the ratio of pupils to full-time teachers, average daily attendance rate, percentage of students who dropped out of high school before graduation, and percentage of high school graduates attending a 4-year college. To combine these 10 variables into an index of high school quality, I use a principal component analysis and use the first principal component. Before the principal component analysis was run, missing values were imputed using the best available subset of the remaining nine variables. As expected, this first principal component gives a positive weight to expenditures, attendance rate, and percentage in 4-year colleges, and gives a negative weight to pupils per teacher, and the high school's drop out rate. This index is then normalized to have a zero mean and a standard deviation equal to one.

- Regarding the computation of the distances that NELS students travel from their home school districts to their four-year colleges: Distances are calculated between the zip code of the college and the student's zip code in 12th grade (or 10th grade or 8th grade if missing). A latitude and longitude for each zip code was found using data from the 1990 census (http://www.census.gov/geo/www/gazetteer/places.html) and augmented by data purchased from Zipwise Software (a division of Thunderwood Holdings, Inc.). Distances are calculated using a formula that accounts for the curvature of the Earth. The median distance traveled was 71 miles. Two students living in remote parts of Alaska had no colleges within 176 miles. For these two students, I used the average quality of colleges in Alaska as an instrument.

8b. Dale and Krueger Method

The following describes the procedure for constructing the dummy variables for groups of "similar" students. During their senior year, NELS students were asked about the colleges at which they had applied. They were asked to identify their first and second choices among their applications. Unfortunately, they were not asked to list the identities of other colleges to which they had applied.[18] For the two colleges listed, they were asked whether they had been accepted or rejected. At the time of the interview in 1992, 64% knew the answer for their first choice and 55% knew the answer for their second choice. In 1994, they were re-asked about admission/rejection and the missing answers from 1992 were filled-in. I take these responses and create a portfolio of

[18] Nonetheless, most students do not send out many more than two applications. The NELS students were asked, "To how many postsecondary schools have you applied?," and given the following choices: none, one, two to four, five or more. Of those who had sent any applications, 39 percent report applying to only one college and only 14 percent applied to more than four colleges. Assuming a geometric distribution produces an estimate that 63 percent applied to only one or two schools and the average student submitted about 2.6 applications.

colleges where the student applied. If they enrolled in a different four-year college from these two, I add the enrolled college to the portfolio (in other words, I treat this as a third application where the student was obviously accepted). I order these two or three colleges based on the college quality, *q*, to determine the student's "best," "second-best," and "third-best" colleges. I identify other students whose first-, second-, and third-best colleges were similar and whose first, second, and third-best college admissions decisions were the same. These students are identified as a group and a dummy variable is established that equals one for these students and zero for all other students.

For colleges to be deemed similar in quality, they need not have exactly the same value of *q*. For example, using median freshman SAT score, I follow Dale and Krueger by splitting the test score distribution into 25 point ranges (e.g. median freshman SAT = 1000-1025, 1025-1050, etc.). This creates about 30 potential college types. Colleges in each range are treated as having similar quality. Likewise, colleges' net tuitions were grouped into ranges of $600, full professor salaries by ranges of $2,500, professor-student ratios by ranges of 0.004, graduate students' share of enrollment by ranges of 0.025, and the index of college quality by ranges of 0.22. In each case, these groupings produce about 30 potential college types.

8c. Black and Smith Method

A logit regression is run with the following specification using the sample of students who attended top- and bottom-quartile colleges (based on *q*):

$$(4.5) \quad \text{Prob}(treated_i = 1) = \frac{e^{X_i\theta + F_i\pi + N_i\alpha + \varepsilon_i}}{1 + e^{X_i\theta + F_i\pi + N_i\alpha + \varepsilon_i}}$$

This equation is then used to predict each student's propensity (P_i) of receiving the treatment. For each treated student a counterfactual outcome is estimated by taking a weighted average of the outcomes of untreated students with similar propensities to receive the treatment. In theory, these students are otherwise similar except for having made a different choice with respect to college quality.

To construct the weights for the untreated students, an Epanechnikov kernel is used. The Epanechnikov kernel gives untreated students the following weight:

$$(4.6)\quad W_{ij} = \begin{cases} (3/4)(1-u_{ij}^2) & \text{if } -1<u_{ij}<1 \\ 0 & \text{otherwise} \end{cases}$$

where $u_{ij} = (P_i - P_j) / B$, i subscripts the treated student, j subscripts the untreated student, and B is the bandwidth used. That is, untreated students with the most similar propensity for treatment as treated student i get the heaviest weights. Those untreated students whose propensity for treatment is outside the bandwidth around P_i get zero weight. The bandwidth, B, is chosen optimally using a "least squares leave-one-out validation mechanism."[19]

Thus, the estimate of the effect of the treatment on the treated student, i, is the difference between the outcome for observation i and the weighted average outcome for untreated students. The estimate of the typical effect of the treatment, β, is the average of β_i. Standard errors for this estimate of β are found by bootstrapping the estimate 500 times, including computation of a new optimal bandwidth each time.

[19] See Black and Smith (2004) for implementation details and Racine and Li (2004) and Pagan and Ullah (1999) for more extensive discussion of the method. Essentially, this method is a search across various bandwidths to find the bandwidth that produces the minimum of the squared difference between y_j and $\bar{y}_{-j}$, where $\bar{y}_{-j}$ is the average outcome for other non-treated students within the bandwidth surrounding P_j. To find this optimal bandwidth, search is conducted here in increments of 0.05 from 0.05 to 1.00.

Appendix Table 1
Predicted Weekly Earnings at Age 40

Variable	Coef.	Robust S.E.	Sig.	P-value for F-test of Joint Sig.
Female	-499	380		
Non-Hispanic Black	-30	18	*	0.404
American Indian	2	46		
Asian American	1	27		
Hipsanic	-22	22		
11th or 12th grade completed, but no HS Grad	44	19	**	0.000
HS Grad / GED	163	13	***	
Some Postsecondary Educ., but No Degree	222	15	***	
Associates Degree	247	17	***	
Bachelors Degree	497	19	***	
Graduate Degree	630	26	***	
Potential Experience	-80	43	*	0.018
Potential Experience^2	4.00	2.18	*	
Potential Experience^3	-0.063	0.036		
Occup. = Cashier, teller, sales clerk	-112	14	***	0.000
Occup. = Clerk, data entry	-2	20		
Occup. = Clerical other	-11	11		
Occup. = Farmer, forester, farm laborer	-149	16	***	
Occup. = Personal service	-147	11	***	
Occup. = Cook, chef, baker, cake decorator	-162	12	***	
Occup. = Laborer (other than farm)	-118	11	***	
Occup. = Mechanic, repairer, service technician	106	15	***	
Occup. = Craftsman	91	14	***	
Occup. = Skilled operative	2	11		
Occup. = Transport operative (not pilot)	18	13		
Occup. = Protective service, criminal justice	82	19	***	
Occup. = Business/financial support service	6	13		
Occup. = Financial services professional	319	23	***	
Occup. = Sales/purchasing	146	13	***	
Occup. = Legal professional	490	57	***	
Occup. = Legal support	119	33	***	
Occup. = Medical practice professional	606	70	***	
Occup. = Medical licensed professional	119	14	***	
Occup. = Medical service	-67	13	***	
Occup. = Educator-K-12 teacher	-34	16	**	
Occup. = Educator-instructor other than K-12	-30	17	*	
Occup. = Human services professional	-90	23	***	
Occup. = Engineer architect software engineer	358	22	***	
Occup. = Scientist, statistician professional	190	39	***	
Occup. = Research assistant/lab technician	128	23	***	
Occup. = Technical/professional worker, other	279	32	***	
Occup. = Computer systems/related professional	384	24	***	
Occup. = Computer programmer	329	39	***	
Occup. = Computer/computer equipment operator	92	39	**	
Occup. = Editor, writer, reporter	144	38	***	
Occup. = Performer/artist	133	29	***	
Occup. = Manager-executive	314	171	*	
Occup. = Manager-midlevel	253	18	***	
Occup. = Manager-supervisory, office, other Administrative	230	15	***	
Occup. = Health/recreation services	-68	62		
Female * 11th or 12th completed, but no HS Grad	-37	18	**	0.000
Female * HS Grad / GED	-83	12	***	
Female * Some Postsecondary Educ., but No Degree	-101	15	***	
Female * Associates Degree	-113	17	***	
Female * Bachelors Degree	-165	20	***	
Female * Graduate Degree	-137	30	***	
Female * Potential Experience	59	58		0.488
Female * Potential Experience^2	-2.87	2.94		
Female * Potential Experience^3	0.045	0.049		
Non-Hispanic Black * 11th or 12th completed, but no HS Grad	7	26		0.096
Non-Hispanic Black * HS Grad / GED	-30	20		
Non-Hispanic Black * Some Postsecondary Educ., but No Degree	-13	23		
Non-Hispanic Black * Associates Degree	-47	26	*	
Non-Hispanic Black * Bachelors Degree	-69	31	**	
Non-Hispanic Black * Graduate Degree	-56	48		
American Indian * 10th grade or less completed	-59	62		0.362
American Indian * HS Grad / GED	-2	65		
American Indian * Some Postsecondary Educ., but No Degree	-43	64		
American Indian * Associates Degree	-28	80		
American Indian * Bachelors Degree	-126	92		
American Indian * Graduate Degree	-244	115	**	
Asian American * 11th or 12th completed, but no HS Grad	0	71		0.107
Asian American * HS Grad / GED	30	32		
Asian American * Some Postsecondary Educ., but No Degree	-19	39		
Asian American * Associates Degree	4	52		
Asian American * Bachelors Degree	-58	41		
Asian American * Graduate Degree	-89	51	*	
Hispanic * 10th grade or less completed	-1	25		0.000
Hispanic * HS Grad / GED	-37	24		
Hispanic * Some Postsecondary Educ., but No Degree	-11	29		
Hispanic * Associates Degree	-46	32		
Hispanic * Bachelors Degree	-154	33	***	
Hispanic * Graduate Degree	-122	53	**	
Constant	974	278	***	

Source: Outgoing Rotation Groups in the 2000 Current Population Survey (CPS), Individuals Aged 35-45.

"***", "**", and "*" indicated two-tailed significance at the 1%, 5%, and 10% levels.

CPS detailed occupations are grouped into NELS occupation groupings. Excluded category = male, white, 10th grade or less completed education, secretary or receptionist. Potential experience = age - 6 - estimated years of education. Estimated years of education = 10 if 10th grade or less completed education; 11.5 if 11th or 12th grade education, but no high school diploma; 12 if high school diploma or GED; 13 if some postsecondary education, but no degree; 14 if associates degree; 16 if bachelors degree; 18 if masters degree; 20 if professional degree; or 22 if doctorate degree. Regression is weighted by CPS variable "pworwgt."

N = 32,475
R^2 = 0.3675