The Effect of College Quality on Earnings
Evidence from Sweden

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Abstract

This paper examines the effect of college quality on earnings using administrative data on Swedish college students. To consider possible heterogeneity, the effects for men and women are estimated separately and quantile regression is used to determine whether the effect of college quality differs over the income distribution. The overall results suggest that the link between college quality and earnings is weak in Sweden. A small positive effect is found for individuals that are likely to work full time as well as for individuals in the upper part of the income distribution, while negative effects are found for individuals located in the middle and lower parts of the income distribution. Furthermore, controlling for region of work affects the estimated effects, indicating a correlation between choice of college quality and choice of labor market region.

Keywords: College quality, Earnings, Selection on observables
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1 Introduction

Several studies have estimated the effect of college quality on earnings and most of them indicate a positive relation. These studies are almost exclusively based on US data. One could expect that the effect of college quality differs depending on the structure of the university system and the conditions on the labor market. This suggests that the US results may not generalize to countries with more centralized university systems.[1] In this paper, we analyze the effect of college quality on students' subsequent earnings in Sweden. The results will contribute to the college quality literature by providing evidence from a country with two distinct characteristics: (*i*) publicly-provided higher education with no tuition fees and (*ii*) a labor market with low wage dispersion.

The US literature on college quality and earnings includes for example Black et al. (2005), Black and Smith (2004, 2006), Monks (2000), Dale and Krueger (2002), and Long (2008). Quality is generally measured by a college's selectivity or by college characteristics that are considered to be correlated with college quality. A common problem confronted in this literature is causality, due to the selection of students into colleges of different qualities. The most common method to address the selection problem is to rely on a selection on observables approach, which is implemented by OLS or by matching. The main result from these studies is that college quality has a positive effect on subsequent earnings. Choice of method does not appear to be of decisive importance for the results.[2] OLS seems to provide the most positive significant results, while matching methods provide estimates of the same size, but with larger standard errors. Evidence for a non-US country is provided by

[1] This is discussed by e.g. Black et al. (2005).
[2] See e.g. Black and Smith (2004) and Long (2008) for a comparison of methods.

Chevalier and Conlon (2003) and Hussain et al. (2009). They use data from the UK and find a positive effect of college quality on wages.

There is a limited Swedish literature related to the effects of college quality, but it focuses on college choice instead of directly conditioning on college quality. In some of these studies, colleges[3] are grouped by age, where older universities are assumed to supply education of higher quality than colleges that were established later. Another approach is to condition on the individual colleges. Recent Swedish contributions in this area include Lindahl and Regnér (2005), Gartell and Regnér (2005), Lundin (2006), and Eliasson (2006a, 2006b).

Lindahl and Regnér (2005) use data on whole siblings to estimate the effect of college choice on subsequent earnings. They find that college graduates from old universities have higher subsequent earnings than college graduates from younger universities. Gartell and Regnér (2005) study the effect on earnings of attending different colleges and find significant effects that can be explained in part by where the individual chose to work after graduation. Lundin (2006) studies a sample of students who graduate from college with a degree in economics or business. He uses a non-parametric regression approach and finds that students who graduate from an old college tend to earn higher initial wages on average than students who graduate from younger colleges. Eliasson (2006a) includes measures of ability and uses OLS to examine the effect on earnings of graduating from five different college groups. In contrast to previous Swedish research, no systematic differences in estimated earnings between the college groups are found. In Eliasson (2006b), propensity score matching is used instead of OLS to estimate the causal effect on earnings of

[3] The terms college and university will be used interchangeably in this paper.

graduating from old universities rather than young universities. No effect of college choice on earnings is found with this method either.

The diverging results in the Swedish studies may be explained by several different factors. The individuals in Lindahl and Regnér are born between 1951 and 1964 while Eliasson uses a sample born between 1969 and 1974 (who graduated during the 1990s). Gartell and Regnér base their study on students who graduated in 1989/90 or 1993/94. This implies that there are large differences in the graduation years between the studies. The students in Gartell and Regnér's study entered the labor market in the first half of the 1990s, a period when Sweden experienced high unemployment. Eliasson's study is based on students who graduated no later than 1998/99. This means that Eliasson includes both students who graduated during a period of high unemployment and students who entered the more favorable labor market in the end of the 1990s. The comparative advantage of studying at an old or selective university could be more important during periods of high unemployment when the employers have a wider selection of applicants to choose from. In periods of low unemployment, employers may not have the same opportunity to sort applicants based on their choice of university. This implies that the different results could be explained by the fact that the effect of college choice differs over the business cycle.

Another possible explanation for the diverging results is that Lindahl and Regnér and Gartell and Regnér may overestimate the effect of college choice due to lack of information about ability. Eliasson includes controls for ability and finds no effect of college choice. In addition, Eliasson aggregates the colleges into two or five groups, based on when they were established. There may be heterogeneous effects within each group, which is hidden by the aggregation. Lastly, Lundin only includes students with a degree in economics

or business. This sample is more homogenous than the other samples, making it difficult to compare the results.

The diverging results from the Swedish studies on the effect of college choice and the lack of European studies on the effect of college quality motivate this study. Even though the results from these previous Swedish studies are often interpreted in terms of college quality, this is the first Swedish study that explicitly studies the effect of college quality itself rather than the effect of studying at different colleges or categories of colleges.[4] Thus, this paper contributes to the existing literature in three ways. First, besides being the first to provide Swedish evidence on the effect of college characteristics on earnings, we contribute to the nearly non-existent European literature on the topic. Since the effect of college quality may differ depending on the university system and/or the labor market structure, evidence from a non-US country is particularly valuable. Second, the data allow us to exclude students who switch universities. Compared to earlier studies, this implies a reduction in the measurement error in college quality. Third, the large number of observations also enables us to consider the heterogeneity among students. Except for some attempts to study men and women separately, the possibility of heterogeneous effects has not been explored in previous studies.

The full sample includes 17,554 students who began studying in 1997 and who received positive earnings in 2005. Our main focus is to estimate the effect of college quality for individuals who are likely to work full time in the outcome year, i.e., we are interested in the effect on productivity rather than on labor supply. To make the estimates more comparable to those obtained when using hourly wages, we follow previous Swedish studies and impose an earnings restriction, which results in a sample of 11,344 individuals. Three college

[4] Lindahl and Regnér (2005) include rate of teachers with a PhD, but their variable is measured with substantial error and they still control for college type.

characteristics that are assumed to be positively correlated with quality will be considered; proportion of teachers with a PhD, teacher/student ratio and grade point average (GPA) from upper secondary school among contemporary college beginners. The variables are introduced both separately and combined into an index. We follow a selection on observables approach to identify the effect of college quality on earnings which is implemented by OLS. The method is motivated by the rich dataset at hand which enables us to control for several variables such as individual characteristics, parental background and college and education history. Ability is measured by GPA from upper secondary school.

We estimate the effect of the individual college characteristics and the college quality index for a sample that consists of both men and women as well as for men and women separately. In addition, we analyze several subsamples as part of a sensitivity analysis. To further consider the heterogeneity of the effect we also estimate quantile regressions on individuals with positive earnings to examine if the effect of college quality differs over the income distribution. The quantile regressions enable us to discuss the impact on labor supply and the implications of the earnings restriction.

The results show that there is a positive effect of college quality on earnings for individuals that are likely to work full time and for individuals in the upper part of the income distribution. Negative effects are found for individuals located in the first half of the income distribution. However, the magnitude of the effects is small, indicating that the link between college quality and earnings is weak in Sweden.

The paper is organized as follows: Section 2 describes institutional background and college quality in Sweden. Section 3 presents the data and Section 4

describes the empirical strategy. The results are presented in Section 5 and concluding remarks are provided in Section 6.

2 Institutional background and college quality

In 2007, there were 322,000 registered students at 50 different state-run or private institutions of higher education in Sweden.[5] Even though the number of educational seats has increased substantially during the last 15 years the demand is still higher than the supply in many fields of study. This implies that the applicants have to be ranked. The ranking procedure is transparent and almost exclusively based on observable factors. The applicants are for the most part ranked by grade point average (GPA) from upper secondary school and scores on the Swedish Scholastic Aptitude Test (SweSAT).[6] It is possible for the colleges to apply other admission criteria, but only for a small proportion of the educational seats.

Financial support for all students is provided by the government and intended to cover living expenses and study material. The study allowance for full time studies amounts to SEK 7,492 per month in 2008 (USD 954)[7], of which one-third is a study grant and two-thirds are study loans.[8] The allowance is independent of parents' or spouse's financial resources but may be reduced for students who earn extra income. There are no tuition fees at Swedish colleges and the provision of higher education is almost entirely public.[9] The public

[5] The statistics are from the Swedish National Agency for Higher Education, referred to as Högskoleverket. See the Swedish National Agency for Higher Education (2008b) for more details on the statistics. For an overview of college education in Sweden, see Öckert and Regnér (2000).
[6] In 1997, applicants with at least five years of work experience had the possibility to add 0.5 points to their SweSAT score and apply in a special category. This possibility disappeared in 2008.
[7] Based on exchange rates in December 2008 (1 USD = 7.86 SEK).
[8] In 1997, when our sample of students began their studies, the corresponding amount was SEK 7,078 per month.
[9] Among the larger providers of higher education in Sweden, the Stockholm School of Economics, Chalmers University of Technology and the University College of Jönköping are run by private sector governing bodies, i.e., they are self-governing and independent.

funding that the institutions of higher education receive for undergraduate education is based on the number of full time equivalent students registered and study achievements (number of study credits obtained by the students). The funding system accounts for the varying per-student cost across disciplines. This implies that, for a given study course, all colleges have the same resources per student.

The central government provides goals and guidelines (mostly financial) while the individual colleges decide on, among other things, the orientation of study programs. The colleges are also responsible for assuring and improving the quality of education. The Swedish National Agency for Higher Education (Högskoleverket) supervises the quality of higher education in Sweden, e.g. by evaluating study programs, appraising the entitlement to award degrees, and auditing the quality assurance procedures at the higher education institutions.[10] The program and degree evaluations consider individual programs, not the whole college. The evaluations are based on a number of criteria, e.g. teaching resources, educational setting, infrastructure, organization and quality assurance of the programs. Some of these criteria are also available in key statistics, while others are more qualitative.

The National Agency for Higher Education adopts a broad perspective when measuring quality, relying on both qualitative and quantitative approaches. The economic literature on college quality has relied on aspects that are easy to quantify and that are likely to capture the latent college quality. Common measures are faculty salaries, net tuition, freshmen retention rate, average SAT scores, teacher/student ratio and rejection rate. Some papers combine information from several quality proxies by factor analysis to produce a quality index.[11] Other studies treat quality as synonymous with selectivity/prestige and

[10] The Swedish National Agency for Higher Education (2008a).
[11] See, e.g., Black et al. (2005), Black and Smith (2006) and Long (2008).

condition on category dummies (selective, less selective). This approach assumes that a more selective college has a higher quality than a less selective college.[12]

According to the results from the National Agency's audits, the quality of higher education in Sweden is largely satisfactory. However, there are large variations between colleges and between different fields of study. For example, in 1997 the proportion year-equivalents performed by teachers with a PhD (measured at college level) ranged from 16 percent to 84 percent. The number of teachers per student varied between 0.02 and 0.21. In addition, since students with higher ability, on average, sort into colleges with higher quality there are also large differences in average GPA.[13]

3 Data and descriptives

The study is based on a dataset of all college students who began studying in spring 1997 or autumn 1997. The dataset is derived from administrative records kept by Statistics Sweden and contains detailed individual data related to college education. The student is followed for up to 12 semesters and the data includes, among other things, registrations per semester, obtained credits per semester, where the student studied each semester, field and level of degree(s) and when the degree(s) are obtained.[14] The dataset also includes information about background characteristics, parental characteristics and school grades.

[12] See e.g. Chevalier and Conlon (2003).
[13] The numbers are own calculations based on the Swedish National Agency for Higher Education (1998). See Table A1 in the Appendix for information about the distribution of quality-related variables over the colleges that are included in our study.
[14] 12 semesters correspond to the maximum number of semesters that a Swedish student can obtain a study allowance.

To control for college quality we include variables that relate to input (proportion of teachers with a PhD, teacher/student ratio) as well as a variable that relates to peer group or selectivity (grade point average from upper secondary school of contemporary college beginners).[15] All measures refer to 1997, i.e. the year that the students began their studies. In accordance with previous studies on college quality, the quality variables are measured on the college level.[16] Using measures on the college level also enables us to compare the results to previous Swedish studies on college choice. Proportion of teachers with a PhD is constructed by dividing number of year-equivalents performed by teachers with a PhD by the number of year-equivalents performed by all teachers. Teacher/student ratio refers to the number of year-equivalents performed by teachers and the number of full time equivalent students.[17]

A new criteria referenced grading system was implemented in compulsory school in 1995 and in upper secondary school in 1994. The criteria referenced grades are on a scale of pass, pass with distinction and pass with special distinction. The old grading system was a norm referenced grading system, with grades between one and five, where five was the highest grade. All students in the dataset have norm referenced grades from compulsory school, while there are some students that have criteria referenced grades from upper secondary school. To make the different grading systems more comparable we use a percentile-rank approach for upper secondary school grades, i.e., we rank the individuals separately in each grading system. This implies that each

[15] The choice of quality variables is guided by previous studies by e.g. Black and Smith (2005) and documents from the Swedish National Agency for Higher Education. A further motivation for the choice of quality variables and a description of how the quality variables enter the equations are found in Section 4.

[16] Table A1 in the Appendix summarizes the colleges included and their respective values for the quality variables.

[17] Proportion of teachers with a PhD and teacher/student ratio are obtained from the Swedish National Agency for Higher Education, see the Swedish National Agency for Higher Education (1998).

student receives a rank between 0 and 100, depending on their ranking relative to the other students. The quality variable GPA of contemporary college beginners refers to the 50th percentile of percentile-ranked grades among college beginners at each college.[18]

The outcome variable, earnings, is measured in 2005 and corresponds to annual earnings from labor (log).[19] We will follow a selection on observables strategy for identification and the empirical strategy will be further explained in Section 4. However, this strategy requires that we observe all variables affecting both the treatment (quality) and the outcome (log earnings). The choice of control variables are based on economic theory and previous research and include basic information about the student (age, sex and children), parental background (age, level of education and origin), college education (field, number of credits and degree) and GPA in upper secondary school.

Earlier studies of the effect of college quality have based the college classification on the first or the last college that the student attended.[20] This necessarily implies a measurement error for all students that switch colleges during their study period (a fairly large group[21]). To eliminate this source of measurement error in college quality, we exclude students who have switched colleges. This means that we can be certain that all students in the sample are matched to the correct quality measure, i.e., we do not introduce measurement error due to incorrect matching of students and college quality. The dataset

[18] Grade point average of contemporary students is derived from the dataset from Statistics Sweden.
[19] The use of a cross-section approach instead of a panel approach is determined by the data at hand. However, Black and Smith (2005) show that their cross estimates of the effect of college quality on log wages are stable over time and that the advantage of using panel data is negligible.
[20] Long (2008) uses the first college that the student attended, Black and Smith (2005) use the last college.
[21] Holmlund and Regnér (2009) find that about one-third of Swedish college entrants study at more than one college.

includes 30,281 students who began studying in 1997 and who only studied at one college. Previous studies on higher education have focused on students who have obtained a degree. However, a large fraction of Swedish students leave college without a degree. In our data, as much as 36 percent did not obtain a degree before 2005. These students do not necessarily drop out, some fulfill the requirements for a degree but have not formally applied for the degree certificate. Therefore, we include both students who have a degree as well as students who have no degree, and include controls for degree attainment and number of credit points.

We assign to each student a college classification based on the college that he or she attended. Students from 26 different colleges are included and the inclusion of colleges is based on college size and earlier Swedish studies on college choice.[22] Some students are excluded due to missing values, predominantly in the variables referring to grades.[23] In addition, some are excluded due to missing variables in parental background. We only consider individuals with positive earnings in 2005, i.e., individuals with zero earnings are excluded.[24] The remaining sample consists of 17,554 individuals.

To be able to estimate the effect of college quality on productivity, a measure of hourly wages is preferred. Unfortunately, since our information about earnings is based on tax records, we only have information about annual earnings. Annual earnings consist of both hourly wages and working hours, implying that the outcome is a combination of both productivity and labor supply choices. One way to reduce the effect of unemployment and labor supply choices is to impose an earnings restriction. Previous Swedish studies

[22] See Table A1 in the Appendix for a list of included colleges. 706 observations are deleted due to their college classification. Students from Stockholm School of Economics are not part of the initial data set due to their use of a different reporting system than the other major colleges.
[23] Grades from upper secondary school are only available for students who left upper secondary school in 1990 or later. This reduces the sample by 10,048 observations.
[24] Requiring positive earnings reduces the sample by 1,319 observations.

on the effect of college choice apply an earnings restriction corresponding to SEK 100,000 per year (see e.g. Eliasson, 2006a, 2006b; Gartell and Regnér, 2005; Lindahl and Regnér, 2005). They rely on Antelius and Björklund (2000) who argue that this level of restriction produces estimates similar to those obtained when using hourly wages. However, Antelius and Björklund estimated the effect of education on earnings for the outcome year 1990. A simple adjustment to 2005 prices and wage level would require an increase in the earnings restriction by around 40 percent. In addition, other aspects from this earlier study are likely to differ from this study (e.g. the income distribution or the composition of the sample).

In order to estimate the effect of college quality for those who have a full time job we choose a higher earnings restriction of SEK 200,000. This restriction corresponds to a monthly salary of SEK 16,666 which is a relatively low salary in a Swedish perspective. By imposing a higher earnings restriction the sample will consist primarily of individuals who actually have a job and who are working full time. Thus, the estimates are more likely to capture the effects on hourly wages, i.e., they will reflect productivity rather than labor supplies. This earnings restricted sample consists of 11,344 individuals.

The choice of earnings restriction is not trivial and it may affect the result. To assess the importance of the chosen level, the models are also estimated with a lower earnings restriction of SEK 150,000. This restriction is closer to the Antelius and Björklund restriction, but adjusted to 2005 years wage level. The results from this sample are only briefly discussed. However, the implications of the earnings restriction will also be further investigated in the quantile regressions in Section 5.3.

Table 1 reports descriptive statistics for the earnings restricted sample. Mean annual earnings from labor are approximately SEK 302,000. About 43 per cent

Table 1: Descriptives

Sample: Earnings restriction	>200,000			
	Mean	Std	Min	Max
Annual earnings in 2005 (100 SEK)	3,016	794	2,001	27,782
Women, %	42.7			
Age in 2005	29.1	2.1	26	57
Children, ages 0-3, 2005	0.20	0.47	0	3
Children, ages 4-6, 2005	0.04	0.22	0	3
Children, ages 7-10, 2005	0.02	0.15	0	3
Children, ages 11-15, 2005	0.01	0.12	0	3
GPA upper secondary, percentile rank	49.0	29.2	0.02	99.9
No degree in 2005, %	36.2			
Number of credits	135	62.7	0.5	414
Field of study, %				
Education	2.2			
Humanities	7.6			
Social science	24.5			
Natural science	17.6			
Technology	30.0			
Agriculture	0.38			
Health care	10.1			
Service and transports	3.9			
Unknown/other	3.8			
Parents' characteristics				
Mother from Sweden, %	93.3			
Father from Sweden, %	93.1			
Mother's age 2005	56.9			
Father's age 2005	59.4			
Mother education, missing , %	3.0			
Mother compulsory, %	22.3			
Mother upper secondary, %	35.6			
Mother college education, %	38.8			
Mother graduate work, %	0.32			
Father education, missing, %	5.8			
Father compulsory school, %	26.0			
Father upper secondary school, %	32.8			
Father college education, %	33.6			
Father graduate work, %	1.8			
College characteristics				
Proportion of teachers with a PhD	0.48	0.20	0.16	0.84
Teacher/student ratio	0.06	0.02	0.02	0.21
Percentile ranked GPA among contemporary students at the same college (p50) (/100)	0.49	0.12	0.31	0.72
Quality index	2.18	1.50	0	7.78
Number of observations	11,344			

are women and 36 percent have not obtained a college degree. Technology, social sciences and natural sciences are the most popular fields of study. Information about parental background shows that approximately 7 percent have a mother or a father that were not born in Sweden. The descriptives also show that 39 percent have a mother with college education or higher and 35 percent have a father with college education or higher.

The descriptives for the non restricted sample (where positive earnings are required for inclusion) are found in Table A2 in the Appendix. The mean values are similar with some exceptions. Since no earnings restriction is imposed, this sample has lower mean annual earnings and a larger proportion of women. A substantially smaller proportion is studying technology, while a slightly larger proportion studies humanities and health care. Finally, the distribution of the quality variables is similar in the two samples.

4 Empirical strategy

We assume that students choose colleges of different qualities based on a belief that the chosen college will raise their discounted lifetime utility more than any other college. The individual's college choice is restricted by the college's available slots, i.e. the individual is also selected by the college. This implies that students are not randomly sorted into colleges of different qualities and that estimating the effect of college quality must deal with selection bias. Non-random selection bias will arise if students choose the quality of a college (or if "quality chooses them") based on the characteristics that also determine expected outcomes. Positive selection is expected where better students sort into colleges of higher quality.

If students sort into colleges non-randomly, selection bias may arise because of the dependence between Q_i and ε_i so that $E(\varepsilon_i | Q_i, X_i) \neq 0$. The selection on observables strategy deals with this problem by assuming that the dependence between Q_i and ε_i is due to observed variables, Z_i. The observable selection variables influence what college quality that the student select and by controlling for them, the selection bias is removed. An earnings equation based on this approach can thus be written

$$\ln Y_i = \alpha + X_i \beta + Q_i \gamma + Z_i \varphi + \varepsilon_i$$

This approach relies on the rather strict assumption that everything that affects both the choice of college quality and the outcome is included in X_i and Z_i. However, when a rich dataset is available, the assumption is less problematic. In our case, the dataset includes a large number of variables that are likely to affect both choice of college quality and earnings, e.g. parental characteristics and grades. In addition, the Swedish college admission procedure is mainly based on observable characteristics of the students. The institutional setting and the rich data set at hand make it plausible to adopt the selection on observables approach. However, when interpreting the results one must always have in mind the possibility that not all bias has been removed. We would expect the college quality effect to be biased upwards by omitted variables, while measurement errors in college quality are expected to bias the effect towards zero.

When implementing the selection on observables assumption in practice, the literature proposes two main methods: regression and matching. One advantage of matching is that it does not impose the linear function form like the regression model does. In addition, matching makes it possible to examine the support condition. However, matching requires discrete groups for comparison, which demands a transformation of the continuous quality

variables into binary or multinomial measures. This transformation results in a loss of information. In addition, regression is more efficient and less complicated to apply.[25] Previous studies also show that the choice of method does not affect the results that much.[26] To avoid losing information, and because of the simplicity of the method, the regression technique is preferred in the present study.[27]

According to Black and Smith (2006), it is not enough to rely on one proxy for quality. College quality is multi dimensional and one single proxy of quality may measure quality with error and introduce bias. Therefore, to capture the effect of quality, three different college characteristics are considered: proportion of teachers with a PhD, teacher per student ratio and grade point average from upper secondary school among contemporary students. These characteristics include both variables that relate to input (proportion of teachers with a PhD, teacher/student ratio) and a variable that relate to peer group or selectivity (grade point average of contemporary students). We recognize that it is difficult to find correct and exact measures of college quality, but argue that these measures are likely to be highly correlated with college quality. In addition, the measures included in the present study are also used in previous studies on the effect of quality on earnings in the US and are further motivated by the fact that they are used in the Swedish National Agency of Higher Education's evaluations of college quality.[28]

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[25] For a more detailed description of matching methods; see, e.g. Heckman et al. (1998) and Imbens (2004).

[26] See e.g. Black and Smith (2004) and Black et al. (2005). Long (2008) finds some evidence of positive selection bias in the OLS results, but that the three alternative methods (the approach proposed by Dale and Krueger (2002), instrumental variables and matching) rarely produce findings that are significantly different from the OLS results.

[27] An alternative to the selection on observables approach is to employ the traditional instrumental variable method. However, it is well known that it is difficult to find valid instruments for education variables. In our case, we have not found any variable that has a significant direct effect on college quality in combination with no effect on earnings. Thus, the instrumental variable technique is not possible to use in the present study.

[28] See, e.g., Black et al. (2005), Black and Smith (2006), Long (2008), and the Swedish National Agency for Higher Education (2008a).

Quality enters the model both as separate variables and as an index. First, we utilize separate college characteristics and estimate the effect of those quality variables using OLS. Since some of the quality variables are highly correlated (see Table A3 in the Appendix), the models are estimated with one quality variable at a time.[29] Control variables are added in different steps, and separate analyses are performed for men and women. Second, a quality index is constructed using the first principal component from a principal component analysis.[30] This index combines the information in the three quality variables into one single measure. The index is included in the equations which are then estimated by OLS.

When using OLS, we model the relationship between our covariates, X, and the conditional mean of our response variable Y (earnings) for a given value of the explanatory variable x. To consider if the effect of college quality varies over the income distribution, we also employ quantile regressions. Originally, Koencker and Basset (1978) suggested quantile regressions as a more robust alternative to OLS.[31] Quantile regression models the relationship between X and the conditional quantiles of Y (for a given x), instead of the conditional mean of Y. Any quantile can be chosen (in our case we use deciles). Quantile regressions have several advantages over OLS. For example, the quantile regression estimator gives less weight to outlier data points of the outcome variable, decreasing the impact such observations may have on the result. In addition, it relaxes the restrictions on the parameters to be constant across the

[29] Table A4 in the Appendix presents the results from OLS regressions when adding all three quality variables at the same time and as a comparison, also the results when introducing them separately into the estimations. The results show that when including them separately (without other covariates), all three have a positive and significant effect on earnings, while when jointly including them only one of them has a positive and significant estimate, the other two are negative and insignificant.

[30] The index is constructed in a similar way as in Black and Smith (2004). The constructed index results in a ranking of colleges that corresponds to our a priori expectations of college quality. For example, the old colleges receive a higher ranking than the more recently established colleges.

[31] The idea behind quantile regression is formally described in Koenker and Basset (1978) and Koenker and Hallock (2001). An application to returns to schooling is provided by Buchinsky (1994).

entire distribution of the dependent variable. In our setting, this is a main advantage since we are interested in whether the earnings restriction affects the result, i.e., if the parameters differ over the distribution.

5 Results

Tables 2-4 present the results for the individual quality variables while Table 5 presents the results for the quality index. To be able to interpret the estimated effect as an effect of college quality on productivity/wages, the analysis will only consider individuals who reported annual earnings above 200,000 SEK in 2005 (corresponding to a monthly salary of about 16,666 SEK). The three quality variables and the index have been introduced separately in the models, i.e., every model has been estimated four times. There are six different specifications. The first specification includes the quality variable and a constant, while specification two adds basic characteristics (sex, age, age squared and children). Specification three also includes parental characteristics (parents level of education, their ages and if they are born in Sweden) and the forth specification adds college education information (field of study, obtained credits and if the student has obtained a degree). The fifth specification adds the student's GPA from upper secondary school to the previous information and this specification is our baseline specification which is used in the quantile regressions and in the sensitivity analysis.

Region of work could be an important determinant of earnings due to, e.g., regional differences in wage levels. The effect of college quality could be biased if students end up at labor markets with different income levels based on which college quality they received. To consider this, we also estimate a sixth model which adds controls for region of work to specification 5. However, since it is questionable to condition on covariates that may be

determined by college quality, it is not obvious to include region of work and specification 5 is still our preferred model.

5.1 OLS estimates

Let us start by considering specification 1-5, i.e. the specifications that do not include region of work. The results for the quality variable Proportion of teachers with a PhD are presented in Table 2. The effect of Proportion of teachers with a PhD is positive and significant for specification 1-5. The effect decreases as more controls are added and for the baseline specification 5 the estimate is relatively small. Comparable results are found for GPA of contemporary college beginners in Table 3. The effect of GPA of contemporary college beginners is positive and significant but small. The results for Teacher/student ratio is presented in Table 4. The effect of Teacher/student ratio is weaker than the effect of the other two quality measures. When only including Teacher/student ratio, and when adding basic controls, the effect is positive and significant but if we add college education controls, the positive effect disappears. However, the less significant results for Teacher/student ratio are not surprising, since the variation is much smaller in that quality indicator.

The Quality index combines the information in the three separate college characteristics into one single variable. Table 5 shows the results for the Quality index. The result of the Quality index is similar to Proportion of teachers with a PhD and GPA of contemporary college beginners, i.e., there is a small positive and significant effect on annual earnings for all specifications. The size of the estimated effect decreases as more controls are added. To consider if the results for the Quality index are driven by one of the quality variables, we have also constructed indexes that combine only two college

Table 2: The effect of Proportion of teachers with a PhD on annual earnings

	(1)	(2)	(3)	(4)	(5)	(6)
Earnings restriction (1000 SEK)	>200	>200	>200	>200	>200	>200
Basic controls	no	yes	yes	yes	yes	yes
Parental controls	no	no	yes	yes	yes	yes
College education controls	no	no	no	yes	yes	yes
GPA	no	no	no	no	yes	yes
Region of work	no	no	no	no	no	yes
Prop of teachers with a PhD	0.100*** (0.011)	0.100*** (0.010)	0.081*** (0.011)	0.086*** (0.011)	0.062*** (0.011)	0.018 (0.011)
Adj. R^2	0.008	0.083	0.089	0.121	0.130	0.178

Note: The number of observations is 11,344. The dependent variable is log earnings in 2005. All regressions include a constant term. **Basic controls** include controls for sex, age, age squared and number of children in four different age categories. **Parental controls** include dummy variables indicating whether the parent is born in Sweden, parents' level of education and parents' ages. **College education controls** include credits, dummy variables for field of study and a dummy variable indicating no college degree. **GPA** is percentile ranked grade point average from upper secondary school. **Region of work** includes dummy variables for region of work. Standard errors are reported in parentheses. ***, ** and * indicate significance on the one, five and ten percent level respectively. Complete results from the regressions are available from the author by request.

Table 3: The effect of GPA of contemporary college beginners on annual earnings

	(1)	(2)	(3)	(4)	(5)	(6)
Earnings restriction (1000 SEK)	>200	>200	>200	>200	>200	>200
Basic controls	no	yes	yes	yes	yes	yes
Parental controls	no	no	yes	yes	yes	yes
College education controls	no	no	no	yes	yes	yes
GPA	no	no	no	no	yes	yes
Region of work	no	no	no	no	no	yes
GPA of contemporary college beginners	0.002*** (0.000)	0.002*** (0.000)	0.002*** (0.000)	0.002*** (0.000)	0.001*** (0.000)	0.000 (0.000)
Adj. R^2	0.010	0.085	0.091	0.122	0.130	0.175

Note: The number of observations is 11,344. The dependent variable is log earnings in 2005. The models are explained in Table 2. Standard errors are reported in parentheses. ***, ** and * indicate significance on the one, five and ten percent level respectively. Complete results from the regressions are available from the author by request.

Table 4: The effect of Teacher/student ratio on annual earnings

	(1)	(2)	(3)	(4)	(5)	(6)
Earnings restriction (1000 SEK)	>200	>200	>200	>200	>200	>200
Basic controls	no	yes	yes	yes	yes	yes
Parental controls	no	no	yes	yes	yes	yes
College education controls	no	no	no	yes	yes	yes
GPA	no	no	no	no	yes	yes
Region of work	no	no	no	no	no	yes
Teacher/student ratio	0.401*** (0.095)	0.388*** (0.092)	0.291*** (0.092)	0.155 (0.095)	0.027 (0.095)	-0.033 (0.093)
Adj. R^2	0.002	0.077	0.085	0.116	0.127	0.175

Note: The number of observations is 11,344. The dependent variable is log earnings in 2005. The models are explained in Table 2. Standard errors are reported in parentheses. ***, ** and * indicate significance on the one, five and ten percent level respectively. Complete results from the regressions are available from the author by request.

Table 5: The effect of the Quality index on annual earnings

	(1)	(2)	(3)	(4)	(5)	(6)
Earnings restriction (1000 SEK)	>200	>200	>200	>200	>200	>200
Basic controls	no	yes	yes	yes	yes	yes
Parental controls	no	no	yes	yes	yes	yes
College education controls	no	no	no	yes	yes	yes
GPA	no	no	no	no	yes	yes
Region of work	no	no	no	no	no	yes
Quality index	0.014*** (0.001)	0.013*** (0.001)	0.011*** (0.001)	0.011*** (0.001)	0.007*** (0.001)	0.001 (0.001)
Adj. R^2	0.008	0.083	0.090	0.121	0.129	0.175

Note: The number of observations is 11,344. The dependent variable is log earnings in 2005. The models are explained in Table 2. Standard errors are reported in parentheses. ***, ** and * indicate significance on the one, five and ten percent level respectively. Complete results from the regressions are available from the author by request.

characteristics. Including these indexes in the models yield similar results as the three-variable index and does not add to the analysis.[32]

To assess the importance of the income restriction, the models are also estimated with a lower earnings restriction corresponding to 150,000 SEK.[33] The results are in the same direction, positive and significant for specification 1-5, but the estimates are somewhat smaller than for the higher earnings restriction. This indicates that college quality has a more positive effect for individuals in the higher income groups than for individuals with lower earnings. The impact of the earnings restriction will be further investigated in the quantile regressions in Section 5.3.[34]

The overall pattern from Table 2-5 shows that college quality has a positive effect on subsequent earnings for individuals who are established on the labor market eight years after they began their college studies. However, the estimated effects are small. If we consider the estimates of specification 5 in Table 5, increasing the quality index by one standard deviation, results in a 1 per cent increase in annual earnings from labor. At mean value of the outcome variable, this corresponds to 251 SEK per month, which is a small reward for a rather large increase in quality.[35] The significance tests of the estimates show that the effect is larger than zero, but the economic value is negligible.

If students who attend colleges of different qualities also sort into different labor markets, and we fail to control for region of work, the effect of college

[32] The results from this sensitivity analysis are found in Table A5 in the Appendix.
[33] The results are not reported here, but could be obtained from the author on request.
[34] We have also estimated specification 5 for a sample with no earnings restriction where only positive earnings are required. When including all individuals with positive earnings, all four quality variables have a negative effect on annual earnings. However, since analyzing the impact of college quality on labor supply lies beyond the aim of this paper this result will not be explored further.
[35] For readers familiar with Swedish colleges, the magnitude of a standard deviation increase in the quality index corresponds to moving from Mälardalen College to Luleå University or from Luleå University to Lund University.

quality could be biased. Therefore, a model which includes region of work has also been estimated. The results are presented in Table 2-5, and correspond to the sixth specification. When including region of work, the positive effect of college quality disappears. The estimate is insignificant for all quality variables, and for Teacher/student ratio it even changes signs. This result implies that the positive effect of college quality could be influenced by the individuals' choice of region to work in. If students from colleges of high quality are more likely to be working in labor market regions with high wage levels, and we fail to include controls for region of work, we may overestimate the effect of college quality. However, since region of work may be endogenous in the earnings equation it is not obvious that it is correct to control for region of work and the results should be interpreted with caution.

5.2 Separate estimates for men and women

The large data set at hand enables us to consider the possible heterogeneity of the effect of college quality. The effect of college quality is not necessarily constant, i.e., the effect could be different for different groups of students. For example, studies based on US data have found that the effect of college quality is weaker for women than for men.[36] Earlier Swedish studies reveal a similar pattern for the effect of college choice, i.e., the effect of college choice is stronger for men than for women.[37] To see if the effect of quality differs by gender, we run separate regressions for women and men. Estimates for specification 5 and 6 are reported. The results are presented in Table 6-9.

[36] See e.g. Black et al. (2005).
[37] See e.g. Gartell and Regnér (2005).

Table 6: The effect of Proportion of teachers with a PhD for women and men

	Women		Men	
	(5)	(6)	(5)	(6)
Earnings restriction 1,000 SEK)	>200	>200	>200	>200
Basic controls	yes	yes	yes	yes
Parental controls	yes	yes	yes	yes
College education	yes	yes	yes	yes
GPA	yes	yes	yes	yes
Region of work	no	yes	no	yes
Proportion of teachers with a PhD	0.054*** (0.014)	0.026* (0.014)	0.061*** (0.016)	0.005 (0.016)
Adj. R^2	0.131	0.179	0.057	0.104
Number of observations	4,842	4,842	6,502	6,502

Note: The dependent variable is log earnings in 2005. All regressions include a constant term. **Basic controls** include controls for age, age squared and number of children in four different age categories. **Parental controls** include dummy variables indicating whether the parent is born in Sweden, parents' level of education and parents' ages. **College education controls** include credits, dummy variables for field of study and a dummy variable indicating no college degree. **GPA** is percentile ranked grade point average from upper secondary school. **Region of work** includes dummy variables for region of work. Standard errors are reported in parentheses. ***. ** and * indicate significance on the one, five and ten percent level respectively. Complete results from the regressions are available from the author by request.

Table 7: The effect of GPA of contemporary college beginners for women and men

	Women		Men	
	(5)	(6)	(5)	(6)
Earnings restriction (1,000 SEK)	>200	>200	>200	>200
Basic controls	yes	yes	yes	yes
Parental controls	yes	yes	yes	yes
College education	yes	yes	yes	yes
GPA	yes	yes	yes	yes
Region of work	no	yes	no	yes
GPA of contemporary college beginners	0.001*** (0.000)	0.000 (0.000)	0.001*** (0.000)	0.000 (0.000)
Adj. R^2	0.131	0.176	0.058	0.104
Number of observations	4,842	4,842	6,502	6,502

Note: The dependent variable is log earnings in 2005. The models are explained in Table 6. Standard errors are reported in parentheses. ***, ** and * indicate significance on the one, five and ten per cent level respectively. Complete results from the regressions are available from the author by request.

Table 8: The effect of Teacher/student ratio for women and men

	Women		Men	
	(5)	(6)	(5)	(6)
Earnings restriction (1,000 SEK)	>200	>200	>200	>200
Basic controls	yes	yes	yes	yes
Parental controls	yes	yes	yes	yes
College education	yes	yes	yes	yes
GPA	yes	yes	yes	yes
Region of work	no	yes	no	yes
Teacher/student ratio	-0.001	-0.030	0.006	-0.084
	(0.117)	(0.114)	(0.145)	(0.142)
Adj. R^2	0.128	0.178	0.005	0.104
Number of observations	4,842	4,842	6,502	6,502

Note: The dependent variable is log earnings in 2005. The models are explained in Table 6. Standard errors are reported in parentheses. ***, ** and * indicate significance on the one, five and ten percent level respectively. Complete results from the regressions are available from the author by request.

Table 9: The effect of the Quality index for women and men

	Women		Men	
	(5)	(6)	(5)	(6)
Earnings restriction (1,000 SEK)	>200	>200	>200	>200
Basic controls	yes	yes	yes	yes
Parental controls	yes	yes	yes	yes
College education	yes	yes	yes	yes
GPA	yes	yes	yes	yes
Region of work	no	yes	no	yes
Quality index	0.006***	0.002	0.007***	0.001
	(0.002)	(0.002)	(0.002)	(0.002)
Adj. R^2	0.130	0.179	0.057	0.104
Number of observations	4,842	4,842	6,502	6,502

Note: The dependent variable is log earnings in 2005. The models are explained in Table 6. Standard errors are reported in parentheses. ***, ** and * indicate significance on the one, five and ten percent level respectively. Complete results from the regressions are available from the author by request.

In contrast to previous studies, the results do not support that men and women have different returns to college quality. For the preferred model, specification 5, the estimates for women and men are similar with some exceptions. The estimates for Proportion of teachers with a PhD, GPA of contemporary college beginners and the Quality index are all positive and significant and of the same size. This indicates that both men and women have a positive effect of college quality, but the effect is very small. Teacher/student ratio differs, with a negative estimate for women while the estimate for men is positive, but none of these estimates are significantly determined. If we turn to specification 6 where region of work is included in the model, all estimates become much smaller, some even turn negative, but besides Proportion of teachers with a PhD for women, all become insignificant. This suggests that both men and women sort into labor markets based on college quality.

5.3 Quantile analysis

The effect of college quality could also vary depending on the student's position in the income distribution. For example, if labor supply decisions are affected by college quality, e.g. if students that have been exposed to a certain quality level are more likely to choose part time work, we would expect heterogeneous effects of college quality on earnings. In addition, if employers recruit students for top positions from top quality colleges, students in the highest part of the income distribution may have a stronger effect of college quality than students in the lower parts. To explore this heterogeneity, quantile regressions have been performed. Since the purpose of the quantile regressions is to explore whether there are differences in the effect of college quality over the income distribution, we include all individuals with positive earnings from labor in 2005, i.e., we use a larger sample than in the earlier estimations where an income restriction was applied. The estimated model corresponds to the

fifth specification, i.e., we control for GPA, but not for region of work. The results are presented in Table 10.

The quantile regressions show that the effect of college quality differs substantially depending on what conditional quantile of the outcome variable that we choose to estimate. Up to the 60th percentile, there is a significant and negative effect of college quality. The effect becomes less negative over the distribution. For the 70th and 80th percentile, there is no effect of college quality, but at the 90th percentile, college quality has a positive and significant effect. When considering the sub samples of men and women, we find diverging results. In the first half of the distribution, the effect is similar, both in magnitude and significance. College quality has a negative and significant effect, both for men and women, with slightly larger negative estimates for men in the bottom percentile. However, if we consider the top percentiles, the results show that the positive effect found for the whole sample was driven by a positive effect of college quality for women. Women have a positive effect of college quality, both in the 80th and the 90 percentile. For men, the effect is negative for all percentiles, but it is not significant in the second half of the earnings distribution.

The quantile regressions reveal that the effect of college quality differs over the earnings distribution, with negative effects in the first half of the distribution and small positive or no effects in the second half of the distribution. Since earnings are a combination of wage and labor supply, the negative estimates in the bottom percentiles are likely to be heavily influenced by differences in labor supplies. There are several reasons to why an individual have low earnings or a low labor supply. The individual could be unemployed or be working part time. Other possible explanations are periods of parental leave or sick leave. Some of these explanations may be correlated with college quality and bias the estimates. Since the effect of college quality on labor

Table 10: Quantile regression estimates of the effect of college quality on earnings

	All	Women	Men
Income percentile	Quality index estimate	Quality index estimate	Quality index estimate
p10	-0.102***	-0.102***	-0.140***
	(0.017)	(0.020)	(0.023)
p20	-0.061***	-0.068***	-0.071***
	(0.009)	(0.014)	(0.010)
p30	-0.033***	-0.031***	-0.029***
	(0.006)	(0.007)	(0.005)
p40	-0.016***	-0.014***	-0.015***
	(0.004)	(0.004)	(0.004)
p50	-0.008***	-0.008***	-0.006**
	(0.002)	(0.003)	(0.003)
p60	-0.004**	-0.002	-0.001
	(0.002)	(0.003)	(0.003)
p70	-0.000	0.000	-0.003
	(0.002)	(0.003)	(0.002)
p80	0.002	0.007**	-0.001
	(0.002)	(0.003)	(0.002)
p90	0.005*	0.008**	-0.003
	(0.003)	(0.003)	(0.004)
Number of observations	17,554	8,954	8,600

Note: The dependent variable is log earnings in 2005. Only individuals with positive earnings are included. All regressions include a constant term, basic, parental and college education controls and GPA. **Basic controls** include controls for sex (excluded for the sub samples of men and women), age, age squared and number of children in four different age categories. **Parental controls** include dummy variables indicating whether the parent is born in Sweden, parents' level of education and parents' ages. **College education controls** include credits, dummy variables for field of study and a dummy variable indicating no college degree. **GPA** is percentile ranked grade point average from upper secondary school. Bootstrap standard errors are reported in parentheses. ***, ** and * indicate significance on one, five and ten percent level respectively

supplies are beyond the scope of this paper, we will not explore this result further. In addition, to understand the impact of college quality on labor supply, a more in dept study that focus on employment and labor market attachment is required.

The results also indicate that college quality is a more important factor for women who reach highly paid positions than for men in the same positions.

These results are conditioned on the individuals GPA, i.e., the positive effect of college quality for women are not likely to be driven by ability sorting. One bold explanation to the difference between men and women may be that women need a signal of competence and ability to be considered for highly paid positions by the employers while men could have a great career regardless of the quality of their education. This explanation is related to women's, on average, weaker position on the labor market, with lower paid jobs and less career opportunities. Another explanation could be that career oriented women, to a larger extent than career oriented men, attend high quality colleges. This unobserved motivation and career focus are not necessarily captured by GPA and the estimates for the highest percentiles for female students could therefore be biased upwards. However, even though a statistically significant effect of college quality is found for women in the highest income percentiles, the economic significance is small and the results should be carefully interpreted.

The results from the quantile regressions also illustrate the implications of the earnings restriction. Obviously, the level of the earnings restriction affects the results. Since the focus in this paper is to capture the effect of college quality on wages/productivity rather than on labor supply, a rather high earnings restriction was imposed. Choosing a lower earnings restriction may produce insignificant estimates while choosing no restriction may result in a negative effect. The quantile regressions also show that there are different effects in different parts of the income distribution, implying that the effect on wages/productivity may differ from the effect on earnings/labor supply.

5.4 Sensitivity analysis

As a sensitivity analysis we have divided the earnings restricted sample into several sub samples to see if there are some groups that are driving the results. The samples are based on parental background, position in the GPA

distribution and fields of degree. The results are found in Table A6-A8 in the Appendix.

Let us start with the sub samples based on parental background. Two samples were formed, one with individuals who had no college educated parents, one with individuals with at least one college educated parent. The results for specification 5 are almost identical for the two groups, indicating that college quality has a similar effect for these two groups of individuals. In addition, the result implies that the unobserved preferences that are related to parental background are not influencing the results.

The second sub samples were constructed based on the individual's position in the GPA distribution and specification 4 is estimated, i.e. we do not control for the individuals GPA. Individuals with higher GPA appear to have a larger positive effect of college quality and for the individuals with the highest GPA, the effect remains even after controlling for region of work. However, students in the highest GPA group are to a large extent attending colleges of high quality and consequently, these estimates are difficult to interpret. In addition, the estimates are relatively small and the economic significance questionable.

In the main samples, both students who obtain a degree and students who end their studies without a degree are included. The controls for field of studies are based on the last course that the student obtains credits for. This is, of course, not a perfect measure of an individual's field of study. However, we have perfect information about field of degree for students who obtain a degree. To see if the effect of college quality varies by field, we estimate specification 5 (without the field controls) for seven sub samples, based on what field the individual has obtained the degree in. The results indicate that the effect of college quality differs by field of study. For individuals with a degree in technology or medicine/social work, college quality has a positive effect, while

it has a negative effect for individuals with a degree in teaching or science. All significant effects, except for science, disappear when adding controls for region of work.[38] However, as for the other estimations, the effects are small. The diverging results for different fields also emphasize the need of field specific quality variables. If college quality varies within colleges, using average values per college introduces bias when students are matched to a quality level that most likely are measured with error.

6 Concluding remarks

The purpose of this paper was to estimate the effect of college quality on students' subsequent earnings in Sweden. The analysis provides some interesting results. First, when only including students who have annual earnings above 200,000 SEK, i.e., individuals who are established at the labor market, college quality has a significantly positive effect. However, the estimates are relatively small, and the economic significance is questionable. When considering women and men separately, similar effects are found. But once again, the effects are very small. A quantile regression analysis was performed to consider if the effect of college quality differs over the income distribution. The analysis showed that college quality has a negative effect in the lower part of the income distribution, while it has a positive effect in the upper part. Separate quantile regressions for men and women showed that men have a negative effect of college quality over the whole distribution, even though the effect is not significant in the upper half. Women on the other hand have a small positive effect in the top percentiles. The quantile regressions provide weak evidence on that women and men gain differently from college quality. A sensitivity analysis also shows that the effect of quality differs by field of study, but not by parental background. The small positive effect of

[38] This result is not reported in Table A8 but is available from the author on request.

college quality is, at least partly, explained by where the individual choose to work after leaving college. There appears to be a sorting of students from high quality colleges to labor market regions with higher income levels, or regions with better possibilities for full time work.

Earlier Swedish studies have estimated the effect of attending different colleges. The results have been diverging, some find an effect of college choice (e.g. Gartell and Regnér, 2005; Lindahl and Regnér, 2005), others find no effect of college choice (Eliasson, 2006a, 2006b). This study confirms the conclusions in Eliasson's studies. College quality and consequently, college choice are not major determinants for students' subsequent earnings in Sweden. What appears to matter more is who you are (ability) and what you study (fields) while the link between college quality and earnings is weak.

The results also indicate a less positive effect than comparable US studies. The US studies mainly find a positive effect of college quality while this analysis finds a positive, but economically insignificant effect on an outcome comparable to wages, and even a negative effect in the lower part of the income distribution. Why does not college quality matter for students' future earnings/wages in Sweden? One explanation could be that the quality variables are measured with error or that they do not capture college quality. However, the US studies use similar quality variables, indicating that measurement error in quality could not be the main reason for the diverging results. A more likely explanation is related to the structure of the university systems and labor markets in the two countries. Higher education in Sweden is mainly publicly provided and the same amount of resources per student is allocated to a given course regardless of which college that provides the education. This implies that all courses in a given field may have similar quality. Even though descriptives show that the quality variables used in this study vary much between colleges, quality audits performed by the National Agency of Higher

Education also indicate that the overall quality is satisfactory. If employers believe that the college quality in Sweden does not differ much and in addition, are relatively high on average, they have less incentive to discriminate wages by college quality. Another possible explanation is that the relatively compressed Swedish wage structure does not give any room for employers to award college quality.

Further research is necessary to explore the importance of college quality. More studies on the heterogeneity of the effect are needed, as well as more evidence from European countries. Exploring if other college characteristics, than the ones included in this study, work as quality indicators, as well as introducing a quality production function are important policy related topics for future research. In addition, including field specific quality variables, to decrease the measurement error in quality that is introduced by using average values per college, is another interesting exercise. It would also be interesting to further investigate the impact on labor supplies by considering other outcomes than earnings, e.g., unemployment and establishment on the labor market.

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Appendix

Table A1: College characteristics

College	Percentage of total students[a]	Proportion of teachers with a PhD	Teacher/ student ratio	Ranked GPA contemporary students (p50)
Lund	8.8	0.69	0.07	57.53
Göteborg	6.0	0.58	0.07	57.53
Stockholm	5.2	0.64	0.05	64.73
Uppsala	7.2	0.72	0.07	60.59
Umeå	7.5	0.65	0.08	44.25
Linköping	9.2	0.45	0.09	58.33
Mid Sweden	5.9	0.24	0.05	31.31
Royal Institute of Technology (KTH)	5.4	0.59	0.08	55.03
Mälardalen	3.7	0.26	0.06	32.52
Örebro	4.0	0.26	0.05	46.43
Luleå	4.4	0.47	0.07	41.64
Karlstad	3.6	0.30	0.05	39.64
Chalmers University of Technology	4.1	0.75	0.08	72.39
Växjö	3.4	0.30	0.04	39.64
Kalmar	2.7	0.29	0.05	35.73
Jönköping	3.1	0.35	0.04	43.69
Gävle	2.4	0.29	0.05	35.41
Stockholm Institute of Education	1.6	0.16	0.06	39.64
Kristianstad	1.9	0.19	0.05	34.75
Dalarna	2.0	0.17	0.05	33.70
Halmstad	1.7	0.29	0.06	36.31
Södertörn	1.1	0.84	0.02	40.27
Borås	1.8	0.21	0.05	34.21
Skövde	1.3	0.30	0.05	38.16
Swedish University of Agricultural Sciences (SLU)	1.4	0.72	0.15	55.03
Karolinska institutet	0.8	0.84	0.21	72.39

[a]The proportions refer to a sample of students who do not change colleges. An income restriction of 200,000 SEK is applied.

Table A2: Descriptives for the non restricted sample

Sample: Earnings restriction	> 0			
	Mean	Std	Min	Max
Annual earnings in 2005 (100 SEK)	2,304	1,209	2	27,782
Women, %	51.0			
Age in 2005	29.1	2.0	26	57
Children, ages 0-3	0.32	0.58	0	3
Children, ages 4-6	0.06	0.26	0	3
Children, ages 7-10	0.02	0.15	0	3
Children, ages 11-15	0.01	0.13	0	3
GPA upper secondary, percentile rank	47.9	28.9	0	99.9
No degree in 2005, %	40.6			
Number of credits	128	63.5	0.3	414
Field of study, %				
Education	2.6			
Humanities	10.4			
Social science	25.5			
Natural science	16.9			
Technology	14.2			
Agriculture	0.35			
Health care	12.1			
Service and transports	4.0			
Unknown/other	3.9			
Parents' characteristics				
Mother from Sweden, %	92.9			
Father from Sweden, %	92.5			
Mother's age 2005	56.8			
Father's age 2005	59.3			
Mother education, missing , %	3.2			
Mother compulsory, %	22.6			
Mother upper secondary, %	35.9			
Mother college education, %	37.9			
Mother PhD education, %	0.35			
Father education, missing, %	6.1			
Father compulsory school, %	26.3			
Father upper secondary school, %	32.9			
Father college education, %	32.7			
Father PhD education, %	1.9			
College characteristics				
Proportion of teachers with a PhD	0.48	0.20	0.16	0.84
Teacher/student ratio	0.06	0.02	0.02	0.21
Percentile ranked GPA among contemporary students at the same college (p50) (/100)	0.49	0.12	0.31	0.72
Quality index	2.18	1.48	0	7.78
Number of observations	17,554			

Table A3: Correlation quality variables

	Proportion of teachers with a PhD	Teacher/student ratio	GPA contemporary students
Proportion of teachers with a PhD	1.00		
Teacher/student ratio	0.52	1.00	
GPA contemporary students	0.80	0.49	1.00

Note: The number of observations is 11,344. An earnings restriction of 200,000 SEK is applied.

Table A4: OLS estimates with all quality variables (column 1) and with each quality variable individually (column 2-4)

	(1)	(2)	(3)	(4)
Proportion of teachers with a PhD	-0.027	0.100***		
	(0.018)	(0.011)		
Teacher/student ratio	-0.169		0.040***	
	(0.112)		(0.095)	
GPA of contemporary students	0.002***			0.002***
	(0.000)			(0.000)
Adj R^2	0.010	0.008	0.002	0.010

Note: The number of observations is 11,344. The dependent variable is log earnings in 2005. An earnings restriction of 200,000 SEK is applied. A constant is included in the regressions. ***, ** and * indicate significance on the one, five and ten percent level respectively.

Table A5: Estimated effects of four different college quality index on annual earnings.

	(1)	(2)	(3)	(4)	(5)	(6)
Earnings restriction (1,000 SEK)	>200	>200	>200	>200	>200	>200
Basic controls	No	yes	yes	yes	yes	yes
Parental controls	No	no	yes	yes	yes	yes
College education controls	No	no	no	yes	yes	yes
GPA	No	no	no	no	yes	yes
Region of work	No	no	no	no	no	yes
Quality index 1 (Prop of teachers with a PhD, Teacher/student ratio, GPA)	0.014*** (0.001)	0.013*** (0.001)	0.011*** (0.001)	0.011*** (0.001)	0.007*** (0.001)	0.001 (0.001)
Adj. R^2	0.008	0.083	0.090	0.121	0.129	0.175
Quality index 2 (Prop of teachers with a PhD, Teacher/student ratio)	0.013*** (0.002)	0.013*** (0.002)	0.010*** (0.002)	0.009*** (0.002)	0.006*** (0.002)	0.001 (0.002)
Adj. R^2	0.005	0.080	0.087	0.119	0.128	0.175
Quality index 3 (Prop of teachers with a PhD, GPA)	0.016*** (0.002)	0.016*** (0.001)	0.014*** (0.002)	0.014*** (0.002)	0.010*** (0.002)	0.002 (0.002)
Adj. R^2	0.001	0.085	0.091	0.123	0.130	0.175
Quality index 4 (Teacher/student ratio, GPA)	0.015*** (0.002)	0.015*** (0.002)	0.012*** (0.002)	0.011*** (0.002)	0.006*** (0.002)	0.001 (0.002)
Adj. R^2	0.007	0.082	0.089	0.119	0.128	0.175

Note: The number of observations is 11,344. The dependent variable is log earnings in 2005. All regressions include a constant term and each model is estimated four times, one for each quality index. **Basic controls** include controls for sex, age, age squared and number of children in four different age categories. **Parental controls** include dummy variables indicating whether the parent is born in Sweden, parents' level of education and parents' ages. **College education controls** include credits, dummy variables for field of study and a dummy variable indicating no college degree. **GPA** is percentile ranked grade point average from upper secondary school. Standard errors are reported in parentheses. ***, ** and * indicate significance on one, five and ten percent level respectively

Table A6: The effect of the quality index for students with or without at least one college educated parent

	At least one college educated parent	No college educated parent
Earnings restriction (1,000 SEK)	>200	>200
Basic controls	yes	yes
Parental controls	yes	yes
College education controls	yes	yes
GPA	yes	yes
Region of work	no	no
Quality index	0.008***	0.008***
	(0.002)	(0.002)
Adj. R^2	0.104	0.142
Number of observations	5,902	5,442

Note: The dependent variable is log earnings in 2005. All regressions include a constant term. **Basic controls** include controls for sex, age, age squared and number of children in four different age categories. **Parental controls** include dummy variables indicating whether the parent is born in Sweden and parents' ages. **College education controls** include credits, dummy variables for field of study and a dummy variable indicating no college degree. **GPA** is percentile ranked grade point average from upper secondary school. Standard errors are reported in parentheses. ***, ** and * indicate significance on the one, five and ten percent level respectively. Complete results from the regressions are available from the author by request.

Table A7: The effect of the quality index for students in different parts of the ability distribution

	GPA 0-25	GPA 26-50	GPA51-75	GPA76-100
Earnings restriction (1,000 SEK)	>200	>200	>200	>200
Basic controls	yes	yes	yes	yes
Parental controls	yes	yes	yes	yes
College education controls	yes	yes	yes	yes
GPA	no	no	no	no
Region of work	no	no	no	no
Quality index	0.004	0.009***	0.005*	0.013***
	(0.003)	(0.003)	(0.003)	(0.003)
Adj. R^2	0.118	0.179	0.134	0.097
Number of observations	3,000	2,882	2,692	2,770

Note: The dependent variable is log earnings in 2005. All regressions include a constant term. **Basic controls** include controls for sex, age, age squared and number of children in four different age categories. **Parental controls** include dummy variables indicating whether the parent is born in Sweden, parents' level of education and parents' ages. **College education controls** include number of credits, dummy variables for field of study and a dummy variable indicating no college degree. Standard errors are reported in parentheses. ***, ** and * indicate significance on the one, five and ten percent level respectively. Complete results from the regressions are available from the author by request.

Table A8: The effect of the quality index for students in different fields of study (the sample only includes students with a degree)

	Teaching	Humanities	Law and social science	Science	Technology	Medicine and social work	Service and transport
Earnings restriction (1,000 SEK)	>200	>200	>200	>200	>200	>200	>200
Basic controls	yes	yes	yes	yes	yes	yes	yes
Parental controls	yes	yes	yes	yes	yes	yes	yes
College education controls	yes	yes	yes	yes	yes	yes	yes
GPA	yes	yes	yes	yes	yes	yes	yes
Region of work	no	no	no	no	no	no	no
Quality index	-0.005**	-0.006	0.006	-0.012*	0.007**	0.008**	0.004
	(0.002)	(0.011)	(0.005)	(0.007)	(0.003)	(0.003)	(0.015)
Adj. R^2	0.154	0.040	0.108	0.070	0.044	0.337	0.049
Number of observations	1,193	169	1,584	613	2,603	884	100

Note: The dependent variable is log earnings in 2005. All regressions include a constant term. **Basic controls** include controls for sex, age, age squared and number of children in four different age categories. **Parental controls** include dummy variables indicating whether the parent is born in Sweden, parents' level of education and parents' ages. **College education controls** include obtained credits. **GPA** is percentile ranked grade point average from upper secondary school. **Region of work** includes dummy variables for region of work. Standard errors are reported in parentheses. ***, ** and * indicate significance on the one, five and ten percent level respectively. Complete results from the regressions are available from the author by request.