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University Quality and Graduate Wages in the UK

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Executive Summary

Analysis of higher education quality has become a central issue in light of UK government policies to introduce variable fees and to encourage more and more young people to attend university. In this context, an important question is whether institutional quality is reflected in labour market earnings. Such information could help to inform students, teachers and policy makers. However, empirical analysis of the link between institutional quality and labour market outcomes is rare outside the US.

In this study we offer an empirical analysis of labour market returns to measures of institutional quality. We exploit the Graduate Cohort Studies for 1985, 1990, 1995 and 1999. We use data from the Higher Education Statistics Agency to obtain information about institutional quality. We use five different measures of quality: research assessment exercise (RAE) score; the faculty-student ratio; the retention rate; the total tariff score (which is based on A-levels or other eligible qualifications); mean faculty salary and expenditure per pupil. We explore how these variables can be combined to an aggregate proxy for quality. We attempt to control for all other variables that might influence both the quality of institution attended by the graduate and his/her wage. Like all studies in this literature, our analysis relies on an (untestable) assumption that relevant variables have not been omitted.

Our key finding is that there is a positive return to attending a higher quality institution for most of the indicators, which is similar to what US studies have found. The earnings differential from

attending a higher quality institution is about 6 per cent on average, when using an overall proxy for quality based on a combination of the measures.

We also examine whether it makes a difference if an individual attends an institution in the second, third or fourth quartile of the quality distribution, as compared to an institution in the first (lowest) quartile. Results suggest that if a student attends an institution in the highest quartile of the RAE score, the retention rate or the total tariff, this leads to higher wages between 10 percent and 16 percent, compared to an individual who attends an institution in the lowest quartile. However, if an individual attends an institution in the second highest quartile of quality, the earning differential drops to 5-7 percent in comparison to the bottom ranked institutions. We also find that returns to institutional quality have increased over time, though within a modest range.

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University Quality and Graduate Wages in the UK[1]

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Abstract
We examine the links between various measures of university quality and graduate earnings in the United Kingdom. We explore the implications of using different measures of quality and combining them into an aggregate measure. Our findings suggest a positive return to university quality with an average earnings differential of about 6 percent for a one standard deviation rise in university quality. However, the relationship between university quality and wages is highly non-linear, with a much higher return at the top of the distribution. There is some indication that returns may be increasing over time.

JEL Keywords: university quality; returns to education
JEL Classification: I23; J24

1. Introduction

Analysis of the quality of higher education in the UK has become a very important issue in the light of government policies to introduce variable fees and to encourage more and more young people to attend university. The analysis of university quality is also important to parents and students when they make decisions about which university to attend. Questions arise as to whether different measures of institutional quality are reflected in labour market outcomes of graduates such as earnings, employment, or occupational positions. A recent survey of students in state schools found that about half believed there was no difference in

[1] We are grateful for funding from the Economic and Social Research Council via its Teaching and Learning Research Programme (TLRP). We would like to thank Peter Elias for providing us with the Graduate Cohort Survey for 1995 and 1999 and helpful advice. We also thank Arnaud Chevalier for his help in using the Graduate Cohort Surveys for 1985 and 1990. We thank Lynsey Pooler, Dominic Rice and Anna Vignoles for helpful comments. We thank participants at a DIUS seminar in December 2008.

the earnings potential of obtaining a qualification in different institutions of higher education.[2] While US research would suggest this conclusion is the wrong one, there is little UK research to guide students, teachers and policy makers about this issue.

In an attempt to fill this gap in the literature, we use Graduate Cohort Studies to estimate returns to measures of higher education institution quality, while controlling for other observable characteristics of graduates. In particular, we closely follow the analysis of Black and Smith (2006), applying some of their approaches in a UK setting. We find comparable estimates of returns to institutional quality. There is also some indication that returns may be increasing over time. We also find some evidence of a non-linear relationship between measures of institutional quality and wages.

We start by a brief review of the literature (Section 2) before describing the data used in this study (Section 3). We then explain our empirical approach (Section 4) and discuss our estimates (Section 5). We then present our conclusions (Section 6).

2. Previous Literature

Since the 1990s, the literature on analyzing the impact of university quality on students' subsequent labour market outcomes has seen a rapid increase. However, most of the research has been conducted in the US. There are two main questions that researchers have to consider when examining the role of the institutional quality on graduate labour market earnings. The first is on how to measure 'quality'; and the second is how to eliminate the effect of unobserved characteristics that influence the probability of admission.

Regarding the first question, early studies have used a measure of average ability of an institution's intake as a measure of quality or prestige. This is typically measured by the

[2] The survey was carried out by PeopleSurve on behalf of CitizenCard. 3113 CitizenCard holders (between age 11 and 24) were asked to complete an online questionnaire. (Source: Sutton Trust Press Release, 21 May 2008).

average SAT scores of first year undergraduates. They find evidence of that institutional quality has a significantly positive impact on earnings.[3] The question has been raised on whether a single proxy variable for college quality is a valid measure of university quality. Black and Smith (2006) examine whether using the SAT score as a proxy for quality is valid and find estimates to suggest that such studies understate the effect of institutional quality on wages. At the same time, they find the SAT score to be the most reliable signal of quality. More recent studies have attempted to broaden the definition of university quality by including a variety of institutional characteristics besides average ability (Black and Smith (2006, 2004), Black, Kermit and Smith (2005), Dale and Krueger (2002).

The second challenge that researchers face when analysing the links between institutional quality and labour market outcomes is that unobserved characteristics of individuals may be related both to their academic achievements in university and to their earnings. Studies attempt to control for many factors that might influence graduate earnings in the labour market. For example, Brewer, Eide and Ehrenberg (1999) model student choice of the type of the institution attended, using information such as the net costs of attending different institutions, and student's academic background. However, attending high quality institutions is found to have an effect on wages even after controlling for such factors.

The most problematic issue is how to deal with attributes of entrants to higher education institutions that may be either unmeasured or poorly measured in available data sets (such as ability). Students of high ability may select (and be selected) into the more elite institutions. If such students earn more in the future, it is not easy to distinguish how much of this is due to the fact they attended higher quality institutions or how much of it is due to their higher average ability. The studies cited above rely on a 'selection on observables'

[3] The early literature is summarized by Brewer and Ehrenberg (1996)

assumption, which means that students are selected into institutions on the basis of variables observed by the analyst. This approach is justified by authors on the basis that they have a rich set of conditioning variables. Dale and Krueger (2002) is one of the few studies that have attempted to deal with the selection problem in a different way. They adjust for selection on the part of schools by comparing earnings and other outcomes among students who applied to and were accepted and rejected by a comparable set of institutions. They find that students who attended more selective colleges do not earn more than other students. However, they find a positive internal rate of return from attending a college with higher resources.

In general, as stated above, studies find evidence for a positive effect of measures of 'college quality' on the subsequent wages of graduates. However, this conclusion is not unanimous and there are a number of controversial issues. Black et al. (2005) point out that findings of positive effects of college quality on earnings are not surprising, until one reflects on similar studies for schools, where it is difficult to find a relationship between school resources and educational attainment (Hanushek, 2003). They conjecture that the difference in the effectiveness of inputs results from differences in market structure – the higher education market is increasingly competitive in the US while the primary and secondary school market is less so. Therefore, they suggest that the finding of positive returns to 'college quality' in the US literature may not generalize to countries with highly centralized university systems. This is something about which there is almost no empirical evidence. Furthermore, the UK system of higher education is more centralized than the US, with fewer private institutions and up until recently, no possible differentiation between public universities in the extent of fees.[4]

[4] Following the 2004 Higher Education Act, variable tuition fees started in 2006/07. However, most institutions charge the maximum permissible fee of £3,000 per annum.

One of the few related studies attempts to look at this issue in the UK (Chevalier and Conlon, 2003), where quality is measured by whether the university is part of an elite group of older universities ('the Russell Group'). Their findings do suggest some positive effect of institutional quality on later earnings. However, the estimates are imprecisely determined and sensitive to specification. Power and Whitty (2008) follow a cohort of graduates over time and show (descriptively) that those who attended elite universities earn more in the labour market. A recent study by Chevalier (2009) follows a similar approach to that applied in this paper. He uses a recently available survey of graduates who left higher education in 2003. His findings are consistent with those reported here. An advantage of the surveys used in this paper is that it is possible to examine returns for different cohorts of students.

Lindahl and Regnér (2005) look at this question for Sweden. They use detailed administrative data that allow one to control for unobserved family and neighbourhood characteristics. They find significant 'within family' effects on earnings, i.e. a premium that appears to differ between siblings depending on where each person went to college. They find that this 'college effect' is correlated with teacher quality, as measured by the proportion of teachers with a doctoral degree.

In summary, on the whole, available evidence suggests that college quality has an effect on earnings. However, this is an area where much more evidence is needed, especially for countries outside the US.

3. Data

This analysis is based on four cohorts of graduates (though focusing most on the most recent cohort): 1985, 1990, 1995 and 1999. The 1995 and 1999 cohorts were surveyed (respectively) 3 and 4 years after graduation and are most comparable in terms of the methodology and the institutions that were used (the surveys were conducted by the same researchers and they

were deliberately designed to be similar). The 1985 and 1990 cohorts were surveyed (respectively) 11 and 6 years after leaving university. For both these cohorts we use wages six years after graduation.[5]

All the surveys are postal surveys. The aim of the 1995 version was to obtain information from five per cent of the population of 1995 qualified leavers from higher education institutions in the UK.[6] Sampling was conducted via a two-stage strategy. In the first stage, a sample of 50 of the targeted institutions was drawn at random, checking that the known characteristics of leavers against those of the target population.[7] In the second stage, a sample of leavers was drawn from each institution (that agreed to take part), initially with a common sampling frame of 50 per cent. For the 1999 survey, it was decided to invite the same sample of institutions to participate (so as to achieve comparability) – although four new institutions were added. In total 33 institutions took part in the 1995 survey and 38 in the 1999 survey. The overall response rates to the 1995 and 1999 surveys were 30 per cent and 24 per cent respectively. Elias (1999) discusses the representativeness of the surveys and shows that female students and mature students are over-represented and ethnic minority students under-represented compared with the population. They find that the survey data and HESA data correspond well in the following subject areas – Law, Maths and Computing, Engineering, Business Studies and 'Other Vocational subjects'. Subjects which are under-represented are Arts (-2%), Languages (-5%) and Natural Sciences (-4%). Subjects which are over-represented are Humanities (+5%), Social Sciences (+4%) and Interdisciplinary subjects (+2%).

[5] Those graduating from university in 1985 were asked retrospective questions about wages 6 years after graduation. There are relatively few unemployed graduates in any of the cohorts.

[6] Those who had studied at specialist medical schools and colleges and other specialist institutions (art/design colleges, agricultural colleges) were not included. Information about the methodology is taken from Elias (1999).

[7] HESA records for the 50 institutions were used to establish that these institutions were broadly typical of the population in terms of gender, regional distribution, age, and type of institution.

Of most importance to us is that the institutions in these surveys are representative of the broader population in terms of our measures of institutional quality. Our measures of institutional quality are as follows: the RAE (Research Assessment Exercise) score; the faculty-student ratio; the retention rate; the total tariff score (i.e. score based on A-levels or other eligible qualifications); mean faculty salary; expenditure per pupil.[8] We show this in Table 1 and find that the institutions represented in the 1999 survey are very similar (and statistically indistinguishable) from all institutions. In Table 2, we show summary statistics of institutional characteristics from the survey of 1985 and 1990 graduates (22 institutions) alongside those from the 1995 and 1999 surveys (33 and 36 institutions respectively).[9] The institutions sampled in 1985/90 look similar to those sampled in 1995/99 on most dimensions. However, the RAE score is lower than for 1995/99. Thus, we should interpret our findings that use all four surveys with caution (which would be a concern in any case on account of the smaller number of institutions used for the first two surveys).

4. Conceptual Framework and Empirical Approach

Our analytical framework is the education production function, where wages W are a function of a vector of university quality measures, Q, and individual characteristics, X: $W = f(Q, X)$. In this case the quality of the higher education institution is represented by a vector of k characteristics so that $Q=(q_1,\ldots, q_m)$. The parameters of interest are the partial effects of the quality variables on wages: $\delta W/\delta q_k$, k = 1, .., m.

To implement this model, we linearise the production function as follows:

8 The measures used are not contemporaneous. In general, we use values of these measures of quality based on their value in 2004. We use measures that are almost contemporaneous for the RAE score (1996 and 2001) with regard to the GCS surveys in 1995 and 1999. We have undertaken some sensitivity analysis using more contemporaneous measures of expenditure per pupil. This makes little difference to our results. It is not possible to improve on what we have done in this respect with regard to either the RAE score (due to the fact that the newer of the HEIs were not assessed prior to 1996) and the total tariff (a fairly recent variable in HESA).

9 The methodology used to select institutions was different for the 1985/90 survey to that conducted in 1995 and 1999. This is explained by Belfield et al. (1997), who show that some characteristics of those surveyed are similar to the wider university population.

$$W_{it} = ß_0 + ß_1 Q_{it} + ß_3 X_{it} + \varepsilon_{it} \qquad (1)$$

where W_{it} is the log wage of individual *i* at time *t; Q,* the quality of the higher education institution, is represented by a vector of characteristics described in the previous section; X is a vector of individual-level characteristics, which include demographics (age and age squared; gender; whether non-white); parental background (mother and father's educational qualifications; whether mother works; whether father works); and characteristics of the individual's education/educational achievement (A-level points score; whether attended private school; subject of degree at university). In some specifications, we also control for class of degree.[10] ε is an error term, which we assume to be normally distributed and uncorrelated with any variable in Q, which also influences wages. Thus, like most of the literature, we assume 'selection on observables', which means that all variables that influence Q and wages are fully captured by the available control variables. In practice, this assumption means that the influence of unobserved factors such as motivation and ambition (on choice of university and wages) are fully captured by observed variables (e.g. A-level points score, subject of degree, parental characteristics etc.).

As noted by Black and Smith (2006) most previous studies employ a single measure of university quality in regression equations such as (1). Implicit in such an analysis is the idea that university quality can be captured by some latent unobserved quality measure q^*, so that $W = f(q^*, X)$. A single observed measure, q_1 say, then proxies the latent quality. Two issues arise in interpreting the parameter of interest, $\delta W/\delta q^*$. First, even if such a model is held to be tenable, q_1 likely measures true quality imperfectly and hence in the presence of classical measurement error, coefficient estimates of quality will be attenuated. Second, and perhaps more importantly, university quality is very likely a multi-dimensional attribute. For

10 Estimates of the effect of university quality on wages are unaffected by controlling for class of degree. We do not control for this in our main specifications as it is itself an outcome of the university attended.

example, institutions may specialize, so that some excel in sciences and others in arts subjects. Furthermore, institutions which perform badly on some measures such as research quality (as measured by our 'RAE' measure) but do well on others, such as teaching quality (arguably proxied by student retention rates). Thus it seems important to incorporate multiple measures of quality in this analysis.

However, whilst incorporating multiple measures of quality in the regression analysis is conceptually appealing, this does create a problem of estimation. Since the university quality measures are highly correlated with one another multicollinearity issues will arise and the estimates on the individual coefficients will be imprecise and difficult to interpret. As shown in Table 3 for the 1999 survey, apart from mean faculty salary (which is weakly – and sometimes negatively - correlated with most indicators), the correlations range from 0.44 to 0.89. We follow two of the strategies used by Black and Smith (2006) – using factor analysis to combine the various measures to obtain a measure of Q; and using an Instrumental Variable Strategy, wherein each quality variable is instrumented by all the other possible variables.[11]

5. Estimates of Wage Returns to Quality

In Table 4, we present OLS regressions for the 1999 cohort where we include quality measures separately and together, with and without controlling for other variables. Results are reported in two panels. Panel A shows estimates of the effect of quality measures on log wages without including any other controls. Columns (1) to (6) reports results where each quality measure is included separately. Then in column (7), the quality measures are included together. In Panel B, we replicate these regressions after including a full set of controls

[11] See Black and Smith (2005) for detail about the methodology. The correlations between the variables used in their analysis range from 0.31 to 0.70. They also explore the use of several other techniques, not used here.

(discussed above).[12] We normalize each of the quality measures to have unit variance (for ease of comparability).

Apart from mean faculty salary (which has a low coefficient and is never statistically significant), all the measures of quality have a positive and significant effect on log wages when included separately. It is interesting to observe how little difference the inclusion of a fairly rich set of controls makes in most of these regressions. When including controls, the coefficient on 'quality' ranges from 2.99 to 4.68 when quality measures are included separately. An interpretation is that a 1 standard deviation increase in the quality of institution attended raises wages by 2.99 and 4.68 percent (conditional on the assumptions of our analysis).

As expected, the picture becomes blurred when all the quality measures are included together (in column 7). This reflects the high collinearity among variables. To improve on this approach, we need to turn to the factor analysis or the Instrumental Variable method. In Table 5, we show the result of combining factors together (i.e. factor analysis) and using the composite variable as a measure of institutional quality in the earnings regression. We show the results of using two factor models and models that combine all variables. In the two factor models, the range of estimates increases to between 4.19 and 9.91, depending on the measures used. In fact, similar measures produce almost exactly the same estimates as in the Black and Smith paper for the US (shown in Table 6). In the models that combine all factors and all factors but the RAE (which is itself a score which takes account of a range of factors), the estimates are 5.3 and 6.46 respectively. Thus, it does seem that using only one measure of institutional quality in regressions leads to downward bias in earnings regressions. At the same time, this estimate is not too far off that which arises from using the total tariff as the sole measure of quality (Table 4). This variable corresponds quite closely to the quality

[12] The full regression results for Table 4, panel B, column 1 is reported in Appendix Table A1.

measure most often used in US research (the SAT score). A similar story is revealed if other quality measures are used to instrument each separate quality measure. This is shown in Appendix Table A2. These estimates are close to the upper range (of about 6%) estimated by Conlon and Chevalier (2003) for the premium attached to attending a Russell Group university.

Two other issues are of interest here. Firstly, have returns to institutional quality changed over time? Secondly, is the measure of institutional quality linearly related to wages? With regard to the first issue, we need to bear in mind that the sample of institutions used in the 1985/90 cohort study is smaller and does not have exactly the same characteristics (in terms of quality) compared to the institutions sampled in the 1995/99 surveys. Furthermore, sample sizes are fairly small in both cases. Notwithstanding these caveats, it is interesting to observe an upward trend in the effect of institutional quality on wages. This is shown in Table 7. Also, within each pair of surveys, the point estimates increase over time - albeit within a modest range, which is not usually statistically significant. However, using the composite measure of quality (after factor analysis) and observing the evolution of the point estimate over time shows quite an impressive change in the effect of institutional quality on log wages. One reason for why one might expect returns to institutional quality to increase over time is the expansion of higher education. With a higher number of graduates available, it is plausible to think of an increasing premium being attached to the quality of institution attended.

A final question is whether or not these measures of quality have a linear effect on wages. To examine this, we re-define variables in terms of quartiles and analyse whether it makes a difference to wages if an individual attends an institution in the second, third or fourth (highest) quartile of the quality distribution, as compared to an institution in the first (lowest) quartile. Results are shown in Table 8. The regressions suggest a non-linear

relationship between measures of quality and wages. For example, if a student attends an institution in the highest quartile of the RAE score, the retention rate or the total tariff, this leads to higher wages of between 10 per cent and 16 per cent (depending on the measure) compared to an individual who attends an institution in the lowest quartile. However if he/she attends an institution the second highest quartile, the earnings differential is 5-7 per cent in comparison with the lowest quartile. There is a positive coefficient for at least some quality measures when comparing an individual who attends an institution in the second lowest quartile and the lowest quartile. However, these differentials are not statistically significant. Thus, the main driver of our results has been individuals who attend higher education institutions in the top quartile of the distribution, though attending an institution in the second-highest quartile also has a benefit.[13]

6. Conclusion

We have considered whether the quality of institution attended has a payoff in the labour market in terms of subsequent wages. Our results suggest that there is a positive return, which is comparable to that found for the US. The magnitude of the return is fairly important as an earnings differential of about 6 per cent for attending a higher quality institution (i.e. 1 standard deviation higher than some alternative) adds up to a considerable sum over a lifetime in the labour market.[14] For example, average earnings for graduates of the 1999 cohort is £22,828. If we assume that the return to quality is 6 per cent of this amount and (very conservatively) assume that this stays constant in absolute terms over his/her time in the labour market, this amounts to a net present value of £35,207 (assuming 25 years in the labour market and using a discount rate of 3.5%). Although this is a high average return to

[13] Note that this paper does not test the impact of attending a low quality institution relative to not attending such an institution at all. Our sample consists of university graduates only.

[14] A one standard deviation increase in the RAE score would mean an increase of about 1 where the scale is from 2 to 5.5.

quality, it is still small by comparison to the overall value of higher education (on average). Blundell et al. (2005) find that the average return to Higher Education is 48% (of earnings) in comparison with leaving school at age 16 with no qualifications. If we translate this into lifetime earnings in the same (very rough) way, this amounts to £281,594. Such evidence suggests that there is some justice in requiring graduates to contribute to the cost of their university education and allowing for differential fees because of a return to the quality of institution attended. Like most papers in this literature, our results are valid only under the (untestable) assumption that the control variables included in the regressions are sufficient to account for the fact that students observed attending high quality institutions are different from those attending lower quality institutions in all respects likely to influence wages. It is noteworthy that better data sets will, in the future, allow for more detailed controls to be included in analysis of this issue. Specifically, pupil-level administrative data sets can be linked from school to university admissions to university attended and then combined with survey data on graduates. This will be a fruitful area for future research.

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Table 1. Summary Statistics of Institutional Measures of Quality

	Institutions in the 1999 Graduate Cohort Survey	All higher education institutions (HESA, 2004)
Research Assessment Exercise (RAE) Score, 2001	3.788 (0.147)	3.754 (0.069)
Faculty-student ratio	0.054 (0.002)	0.058 (0.002)
Retention Rate	0.903 (0.008)	0.909 (0.004)
Total Tariff (average pre-university test score – A-level or equivalent)	0.929 (0.091)	0.816 (0.047)
Mean faculty salary/1,000,000	0.035 (0.001)	0.036 (0.000)
Expenditure per pupil/10,000	1.025 (0.098)	1.302 (0.213)
Number of institutions	36	136

Table 2: Summary Statistics of Institutional Quality Measures from the Graduate Cohort Surveys

	1985/1990	1995	1999
RAE Score	2.984 (0.199)	3.791 (0.150)	3.788 (0.147)
Faculty-student ratio	0.053 (0.002)	0.055 (0.002)	0.054 (0.002)
Retention Rate	0.907 (0.007)	0.906 (0.009)	0.903 (0.008)
Total Tariff	0.890 (0.124)	0.901 (0.094)	0.929 (0.091)
Mean faculty salary/1,000,000	0.038 (0.001)	0.035 (0.001)	0.035 (0.001)
Expenditure per pupil/10,000	0.989 (0.100)	0.990 (0.089)	1.025 (0.098)
Number of institutions	22	33	36

Table 3: Correlation between Institutional Quality Variables (1999 cohort)

	Rae Score	Faculty-Student Ratio	Retention Rate	Total Tariff	Mean Faculty Salary	Expendture per Student/10000
Rae Score	1					
Faculty-Student Ratio	0.728	1				
Retention Rate	0.769	0.443	1			
Total Tariff	0.874	0.615	0.783	1		
Mean Faculty Salary	-0.048	-0.376	0.051	-0.029	1	
Expendture per Student/10000	0.803	0.886	0.554	0.748	-0.276	1

Table 4. Log Wage regressions for Graduate Cohort Study, 1999

A. Regressions without other controls

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
RAE Score	4.65						-4.37
	(1.55)						(3.06)
Faculty-Student		4.11					-1.83
Ratio		(1.33)					(2.56)
Retention Rate			4.93				2.84
			(1.53)				(1.98)
Total Tariff				5.52			3.36
				(1.53)			(2.72)
Mean faculty					-1.27		0.03
salary/1,000,000					(1.65)		(0.95)
Expenditure per						5.51	6.57
pupil/10,000						(1.33)	(2.92)
N	6465	6465	6465	6465	6465	6465	6465
R-Squared	0.01	0.01	0.02	0.02	0.00	0.02	0.03

B. Regressions with controls

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
RAE Score	4.03						-4.63
	(1.24)						(2.49)
Faculty-Student		2.99					-1.42
Ratio		(1.09)					(2.11)
Retention Rate			4.42				2.77
			(1.14)				(1.66)
Total Tariff				5.87			4.98
				(1.23)			(2.58)
Mean faculty					-1.12		-0.37
salary/1,000,000					(1.06)		(0.76)
Expenditure per						4.68	4.91
pupil/10,000						(1.25)	(2.56)
N	6465	6465	6465	6465	6465	6465	6465
R-Squared	0.12	0.12	0.13	0.13	0.12	0.13	0.14

Note: Coefficients reported and standard errors in parenthesis. All coefficients are multiplied by 100; and standard errors are clustered at the institution level. The institution quality measures are normalised to have unit variance. Controls include the individual's A-level points score, gender, age and age squared, whether mother works; whether father works; whether attended private school; whether non-white; whether father (mother) is educated to degree level, has some higher education, O-levels, number of O-levels; A-levels; Dummies for subject of degree at university.

Table 5: Factor Analysis

Two Variable Models	
Factor combines faculty student ratio and the retention rate	7.24
	(1.79)
Factor combines faculty-student ratio and total tariff score	6.52
	(1.42)
Factor combines retention rate and total tariff	6.35
	(1.29)
Factor combines retention rate and total tariff	5.38
	(1.32)
Factor combines retention rate and RAE score	9.91
	(3.84)
Factor combines faculty student ratio and expenditure per pupil	4.19
	(1.38)
Factor combines retention rate and expenditure per pupil	7.65
	(1.58)
Factor combines total tariff and expenditure per pupil	6.95
	(1.27)
Factor combines RAE score and expenditure per pupil	5.39
	(1.45)
Factor combines total tariff and RAE score	5.65
	(1.26)
Factor combines retention rate and RAE	5.37
	(1.32)
Factor combines staff salary and expenditure per pupil	5.53
	(2.05)
Factor combines staff salary and RAE	9.91
	(3.84)
Factor combines faculty student ratio and RAE score	4.57
	(1.38)
Five (or more) Variable Models	
Factor combines all quality indicators apart from RAE score	6.46
	(1.21)
Factor combines all quality indicators including RAE score	5.30
	(1.21)

Note: includes controls as in Table 4.

Table 6: Comparison with Black and Smith (2006)

Two Variable Models		
	Our estimates	Black and Smith's estimate*
Factor combines faculty student ratio and the retention rate	7.24	8.00
	(1.79)	(3.31)
Factor combines faculty-student ratio and total tariff score	6.52	6.10
(mean SAT scores for Black and Smith)	(1.42)	(2.78)
Factor combines retention rate and total tariff	6.35	5.60
(mean SAT scores for Black and Smith)	(1.29)	(2.25)

*Coefficients and standard errors multiplied by 100

Table 7: Estimated coefficients from using different Graduate Cohort Surveys

	1985	1990	1995	1999
RAE Score	2.88	3.32	4.28	4.03
	(0.86)	(1.54)	(1.15)	(1.24)
Faculty-Student Ratio	1.69	3.13	2.23	2.99
	(0.85)	(1.34)	(0.74)	(1.09)
Retention Rate	1.24	1.48	3.77	4.42
	(0.98)	(1.39)	(0.98)	(1.14)
Total Tariff	3.58	3.82	4.42	5.87
	(0.78)	(0.70)	(0.93)	(1.23)
Mean faculty salary/1,000,000	1.50	2.77	0.38	-1.12
	(1.06)	(1.29)	(1.15)	(1.06)
Expenditure per pupil/10,000	2.88	3.56	2.14	4.68
	(0.58)	(1.23)	(0.64)	(1.25)
All factors apart from the RAE score	2.36	3.83	4.67	6.46
	(1.10)	(1.71)	(1.12)	(1.21)
All factors including the RAE Score	2.68	3.43	3.27	5.30
	(0.86)	(1.59)	(0.85)	(1.21)
N	2435	3744	6612	6465

Note: includes controls as in Table 4.

Table 8: Wage regressions when measuring institutional quality by ranking in the distribution compared to lowest quartile

	RAE	Faculty-Student Ratio	Retention Rate	Total tariff	Mean faculty salary/1,000,000	Expenditure per student/10,000
Lowest quartile (reference)	--	--	--	--	--	--
2nd lowest quartile	-2.52	-2.61	5.50	3.88	-7.62	-5.37
	(3.80)	(3.07)	(2.73)	(4.52)	(3.48)	(3.17)
2nd highest quartile	5.32	-2.05	5.87	6.77	-8.21	-3.71
	(2.50)	(5.02)	(4.44)	(2.54)	(4.69)	(4.73)
Highest quartile	10.32	4.18	12.32	16.14	-3.28	4.71
	(3.56)	(3.72)	(4.04)	(3.74)	(3.10)	(3.36)
R-squared	0.13	0.12	0.12	0.13	0.12	0.13

See notes to Table 4. N=6465. All controls included

Appendix Table A1:
Log Wage Regressions for 1999 Graduate Cohort Study, Full Set of Controls

RAE score	4.03
	(1.24)
A-level point score tercile = 2	1.37
	(1.85)
A-level point score tercile = 3	6.52
	(1.67)
Female	-10.73
	(1.38)
Age	11.98
	(11.77)
Age squared	-0.18
	(0.22)
Father works	0.76
	(2.58)
Mother works	1.67
	(1.33)
Attended private sechool	8.06
	(1.84)
Non-white	4.40
	(3.24)
Mother education = degree	2.27
	(2.37)
Mother education = some higher education	-0.35
	(2.31)
Mother education = A-levels	3.45
	(1.93)
Mother education = O-levels	3.01
	(2.28)
Mother education = no O-levels	3.12
	(2.49)
Father education = degree	6.54
	(2.56)
Father education = some higher education	7.23
	(2.50)
Father education = A-levels	9.27
	(2.33)
Father education = O-levels	7.34
	(2.65)
Father education = no O-levels	4.67
	(2.22)

(table continues next page)

Appendix Table A1 (cont.)
Log Wage Regressions for 1999 Graduate Cohort Study, Full Set of Controls

Degree Subject:	
Humanities	1.66
	(2.12)
Languages	7.52
	(2.73)
Law	24.94
	(3.57)
Social Sciences	6.77
	(2.08)
Maths and Computing	26.51
	(2.83)
Natural Sciences	1.58
	(2.42)
Medicine and Related	27.02
	(5.35)
Engineering	16.70
	(1.92)
Business Studies	20.61
	(2.62)
Education	16.73
	(2.27)
Interdisciplinary	13.96
	(4.35)
Other Vocational	13.34
	(2.42)
Degree subject missing	8.91
	(4.88)
Observations	6465
R-squared	0.12

Note: This table reports coefficient estimates for the full set of controls used for the regression in Column 1, Table 4B. Coefficients reported and standard errors in parenthesis. All coefficients are multiplied by 100; and standard errors are clustered at the institution level. The institution quality measure, RAE, is normalised to have unit variance. For Degree Subject the omitted category is Arts degree.

Appendix Table A2: Instrumental Variable Strategy

	OLS estimate	IV estimate
RAE Score	4.03	6.39
	(1.24)	(0.64)
Faculty-Student Ratio	2.99	4.24
	(1.09)	(0.58)
Retention Rate	4.42	5.62
	(1.14)	(0.68)
Total Tariff	5.87	6.23
	(1.23)	(0.69)
Expenditure per pupil/10,000	4.68	4.62
	(1.25)	(0.61)
N	6465	6465

Note: includes controls as in Table 4. All controls included.
Coefficients are from separate regressions. In column 2, each quality measure is instrumented using all the other quality measures.