“Does it pay to attend a prestigious university?”

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Executive Summary

The United Kingdom higher education system has to date been characterised by all undergraduate students paying a unique price irrespective of the institution attended. Recently, a group of research-orientated universities has been arguing that the higher average earnings achieved by their graduates stems from the quality of the teaching provided. As the provision of high quality teaching is costly, these institutions have lobbied for the right to charge higher fees.

This claim that prestigious institutions provide higher financial returns to their graduates has not been clearly illustrated to date. As more prestigious university attract students of higher academic ability and with different backgrounds than students registering at modern institutions, a simple comparison of the earnings can be misleading as it does not account for pre-university personal and academic characteristics.

Using three cohorts of graduates in 1985, 1990 and 1995, we control for the selection of individuals into different types of university using a Propensity Score Matching method. We show that there are substantial variations in the quality of the teaching provided as reflected by differences in the wages achieved by graduates attending different types of higher education institution.

Specifically, even after accounting for personal characteristics graduating from a Russell Group institution adds between 0 and 6% to an male graduate's earnings compared to graduating from a Modern university and 2.5% for women in the younger cohorts Teaching Quality as represented by earnings returns within different types of institution also differs widely. The effects of teaching quality on wage growth are unclear and we are unable to conclude whether quality effects result in temporary or permanent increases in earnings. There is also some evidence that with the expansion of higher education, the heterogeneity between institution types has increased while heterogeneity within types has decreased.

We use these estimates of the returns to the type of institution attended to predict prices in the higher education market if institutions were left with the freedom to set their tuition fees. Under various scenarios, we estimate a fee differential between prestigious and less prestigious universities ranging from £2,950 to£7,250. This range of tuition fees is in line with the current inter-quartile range observed in the US among private institutions. A tuition fee differential of £4,000 is also equivalent to the reported differences in academic expenditures between the institutions but larger than the maximum top-up fee proposed in the current government White Paper (£3,000). These results suggest that by implementing a unique price of higher education, the government currently subsidises graduates attending more prestigious institutions more generously than others and that there is some justification in the claim that institutions should be allowed greater freedom in setting their tuition fees.

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1 Introduction

The literature on the returns to education has mostly estimated private returns for an average individual. These estimates have been widely used to encourage individuals to seek tertiary education. For example, the United Kingdom Government's recent White Paper introducing tuition fee reforms states that "on average those with higher education qualifications earn around 50% more than non-graduates" (HMO 2003)[1]. However, average returns may be misleading, and this paper aims to document some of the variation in the returns to higher education in the United Kingdom.

Currently, the United Kingdom higher education system imposes a unique price, irrespective of the subject of the degree studied or the institution attended. A group of research-orientated universities has been arguing that the higher average earnings of their graduates stems from the quality of the teaching provided. As teaching quality is costly to provide, some of these institutions have lobbied for the right to charge higher fees[2]. The claim that prestigious institutions provide higher financial returns to their graduates has not been clearly illustrated to date. The difficulties in comparing the returns to different institutions or types of institution originates from the heterogeneity of the student populations attending the various types of institution and differences in the undergraduate degree courses provided (academic or more vocational courses). Due to these selection issues, a simple comparison of the earnings associated with graduates attending different institutions can be deceptive[3].

This paper aims to provide evidence that returns to higher education vary by the type of institution attended even after accounting for the heterogeneity of students. If such evidence is found, arguments in favour of differentiated tuition fees could be justified. Having a unique price for goods of differing quality would provide an implicit subsidy to graduates attending 'prestigious' institutions, which could be seen as an inequitable policy.

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[1] The 50% premium described refers to the difference in average earnings between those with either undergraduate of sub degree qualifications compared to those with qualifications strictly below sub degree level (Level 3 and below). This estimate is a comparison of the average earnings of the two groups and is not regression based. It cannot therefore be considered a return in the general sense.

[2] Following this lobbying, the White Paper on higher education (HMO 2003) has indeed allowed every university the right to charge additional fees to undergraduates provided they meet specific requirements on widening participation for those individuals from 'non-traditional' university backgrounds.

[3] Subject of degree and institution also impact on the probability of employment, post-graduate studies (Conlon and Chevalier, 2002) or over-education (Chevalier, 2002), but these issues are neglected in this paper.

Due to selection effects, estimating returns to quality in higher education is not straightforward. First, as in the bulk of the literature, we assume linear selection on observables; i.e. we control for characteristics that should affect the choice of individuals entering different types of institution. However, Black and Smith (2002) have recently shown the limit of such estimates, and in particular, two primary weaknesses are identified. First, if the sorting of individuals and institutions by ability is perfect (or close enough), no talented individual will be observed in a less prestigious institution and similarly no less able student would be observed attending a prestigious institution. Thus, institution effects will be identified solely by the imposed functional form. This is traditionally referred in the literature as the absence of common support problem. Secondly, even if the selection to an institution is based on observable variables, the estimates may be biased if the relationship is non linear.

As an alternative estimation strategy, we rely on propensity score matching (Rosenbaum and Rubin, 1983). This estimation strategy identifies institutional effects by pairing each individual in a prestigious institution with a "similar" individual in a less prestigious university, thus not imposing a functional form. This estimation also highlights the difficulties associated with the absence of common support between the two populations of students.

In the literature, estimates of quality effects in higher education on earnings are ambiguous. Similarly, we find mixed evidence of quality effects in higher education in the United Kingdom. Our analysis is based on three cohorts of graduates (1985, 1990 and 1995), who were surveyed respectively 11, 6 and 3 years after leaving university. According to the results of our preferred model specification, we estimate that male graduates from a prestigious institution earn between 0 and 6% more than graduates from Modern universities. Equivalent female graduates from the more recent cohorts earn approximately 2.5% more than female graduates from Modern Universities. The evolution of the premium is consistent with higher education in the UK becoming more differentiated as it expends. Thus, the premium for attending a prestigious institution is larger for the younger cohort than for the older one. For females the results are somewhat biased by selection effects. We find that there is no premium for attending an old university (non Russell Group) compared to attending a Modern Universities. The quality of teaching has ambiguous effect on wage growth but we tentatively support the assumption that the quality effects originates from an increase in human capital.

In order to highlight the current debate about university top-up fees in the United Kingdom, we simulate the lifetime effect on wages of attending a prestigious institution and calculate the fee differential that would equilibrate the returns to higher education between the different types of institution. Under various assumptions, we report that a tuition fee differential ranging from £3,000 to £7,000 would be expected if institutions were left with full freedom to set their tuition fees. Since the differences in per student academic expenditures between the institutions are in the lower part of this range, there is little evidence that prestigious institutions are more cost effective at providing education than less prestigious universities.

2 The United Kingdom Higher Education system

University education is almost universally provided in publicly funded institutions. A primary aim of many UK governments since the 1960s has been to increase the proportion of a cohort attending some type of tertiary education. In the 1960s, this aim

led to the creation of several new higher education institutions. The upward trend in participation has been steep with at least a 50% increase in the age participation index (API) each decade. By 2000, 33.4% of a cohort aged less than 21 was in full-time undergraduate studies compared to 5.4% in 1960. The increase in participation has been concomitant with an increase in the demand for skills, so that the average private return to a degree has remained relatively constant over the last two decades (Chevalier and Walker, 2001). It can also be noted, that participation is much higher for middle class students than for those at the bottom of the social class distribution. In fact the gap between these two populations has increased consistently over the period (Table 1)[4].

To accommodate the drastic change in participation, the higher education sector was substantially reformed in the 1990s. Prior to 1992, the United Kingdom higher education sector was characterised by two mutually exclusive components. One sector comprised research led institutions with degree awarding powers (traditional universities) and the other sector comprised polytechnics, which did not have full degree awarding powers and provided courses in more vocational orientated subjects. In 1992, this degree awarding distinction disappeared and all higher education institutions were granted university status and degree awarding powers. We refer to the former polytechnic institutions as New or Modern Universities. The institutions that possessed degree-awarding powers prior to 1992 are generally referred to as Old universities. Within the Old universities, a self selected informal coalition of 19 research led institutions, often considered to encompass the oldest and most prestigious higher education institutions within the United Kingdom, has been formed. This group of institutions is referred as the Russell Group[5]. Thus, three types of universities can be defined: Russell Group, Old universities and Modern universities. The three types of university differ by the degree subjects offered and the emphasis placed on research and as a result their sources and volume of public funding. This hierarchy is used to approximate the quality of an institution.

2.1 Proposed changes to the system

The United Kingdom has a long tradition of a unique price for higher education with the government subsidising higher education institutions[6]. However, in order to keep higher education budget under control, per student funding has fallen continually as the number of students has increased. In particular, between 1989 and 1997 per student funding decreased by 36% (HMO, 2003). This prolonged lack of funding in higher education has lead to what is perceived as a funding crisis in the sector. Following extensive lobbying by some of the Russell Group universities, reforms have been proposed to allow universities the freedom to differentiate their fees by

[4] See also Wolf (2002) chapter 6 for more evidence on the increasing gap in university attainment by social class.

[5] The members of the Russell Group are as follows: University of Birmingham, University of Bristol, University of Cambridge, Cardiff University, University of Edinburgh, University of Glasgow, University of Leeds, University of Liverpool, University of Manchester, University of Newcastle upon Tyne, University of Nottingham, University of Oxford, University of Sheffield, University of Southampton, University of Warwick, Imperial College, King's College London, London School of Economics and University College London.

[6] Prior to 1998, attendance at any higher education institution was free. In 1998, a means tested tuition fee was introduced in England and Wales irrespective of the institution attended or the subject studied. The current fee increases in line with inflation (£1,100 per annum). Students eligible for the tuition fee currently pay this cost up front and repay maintenance loans after graduation contingent on their income. See Appendix for detailed information on the current funding arrangements.

subject and encourage them to be more financially independent of central government[7].

An entirely deregulated market has not been introduced. Tuition fees have been capped to a maximum £3,000 per annum and universities will only have the right to change differentiated fees if they sign an agreement with the newly formed access regulator to ensure that those individuals from non traditional university backgrounds are not discouraged from attending for financial reasons. These reforms appear to acknowledge that institutions are heterogeneous in the quality and cost of the teaching provided.

3 'Teaching Quality' and returns to Higher Education

Despite the large increase in the proportion of a cohort graduating, there is no clear evidence that returns to degrees have fallen over time. Harkness and Machin (1999), using the General Household Survey between 1979 and 1995 and Walker and Zhu (2002), using Labour Force Survey throughout the 1990s, report no particular trend in the returns to a degree during the period. The authors' estimates of the return to an undergraduate degree range between 14% to 23% for men and 16% to 26% for women[8]. These estimates are generally consistent with existing estimates of the returns to the number of years of schooling and the fact that returns are greater for women than for men. This would suggest that the demand shift in favour of the more educated has been at least as large as the supply shift in favour of tertiary education. These studies also provide evidence of heterogeneity in the returns to a degree by subject with Maths and Engineering leading to higher returns than average whilst the opposite is true for graduates from Humanities and Arts degrees. However, the issue of the quality of an institution on the earnings of graduates has largely been ignored.

Most of the literature on the quality of education has focused on schools. Evidence concerning higher education is sparse and inconclusive. In the United Kingdom, Naylor *et al*. (2000) use administrative data on the population of individuals graduating from Old universities in 1994. Among this selective group of universities the authors find that mean weekly earnings range from £370 and £430 and conclude that, "universities explain only a small fraction in the differences in graduates' earnings profiles". The study has some important caveats: first, the selected institutions are more homogenous than the universe of higher education institutions in

[7] The current reforms will also move the burden of payment to after graduation. Students will remain eligible for maintenance loans and grants. As before, the debt accumulated will be repaid following graduation though the tax system and will be income contingent. These changes to the timing of the payment of fees were proposed in order to mitigate the financial constraints of higher education for students from lower socio economic groups.

[8] These estimates are obtained by using individuals with A-levels as their highest qualification as a control group. Some studies have recently accounted for selection into university. Ermish and Francesconi (2000) rely on parental wealth and maternal education levels to estimate a selection equation into higher education. The selection term is always significant in a wage equation, but only marginally affects the estimated returns. Using the National Child Development Study (NCDS), Blundell et al (2001) follow a similar strategy, and rely on parental wealth, interest in the child's education and the number of siblings as identifying variables of the selection equation. These variables are also used as instruments for the qualification decision. Additionally, they estimate the returns to education by propensity score matching. Unlike Instrumental Variables (IV) and selection controlled estimates, which are significantly higher than OLS estimates, matching results are not substantially different. The authors conclude that since IV and selection controlled estimates are larger than OLS, this suggests that OLS regression may compensate selection bias with measurement error.

the UK; second graduates are surveyed six months after leaving university and their earnings are imputed from the occupation occupied at that time, which may be a poor proxy for life-time earnings. Belfield and Fielding (2001) rely on the 1996 survey of graduates and investigate the relationship between universities' input, in the form of student-staff ratios and subject adjusted resources, and students' financial outcomes, but cannot find any quality effect. Their estimates could be biased since no correction for the selection of students into a specific university is included, apart from the control for A-level score. Their measures of quality focusing on students-staff ratio and unit resources may also be inappropriate if quality is only loosely related to these characteristics.

On the other hand, evidence from the US of college quality effects is prevalent. Brewer *et al*. (1999) for example conclude that even correcting for selection into the type of university (using estimated net costs), prestigious private institutions provide significantly higher financial returns compared to low cost public institutions. These returns increase through time within and between cohorts (NLSY, High School and Beyond 1982) concomitantly with the fee differential. Whilst Daniel *et al*. (1997) confirm that fee differentials are in line with quality differentials, they criticise the parametric approach in the rest of the literature. Black and Smith (2002) therefore rely on propensity score matching to estimate the long run effect of institution quality on earnings. Attending a top quality university increases earnings by about 6% for men and 10% for women, however, their estimates are imprecise due to small sample sizes[9]. These results of the positive effect of institutional quality on earnings are contradicted by Berg, Dale and Krueger (2002). Using information on the university a graduate attended but also those the individual applied to, the authors claim to be able to control for selectivity on unobservables, as well as observables. In doing so, they find no financial return to attending a more selective institution. Results may also be sensitive to the measure of quality and the variety estimation strategy. Cross-country differences in the returns to university quality may also be due to the greater competition and heterogeneity between universities in the US than in the UK (Hoxby, 1997).

3.1 Modelling Strategy

A simple model of the decision process of potential students has the following form. We assume that the quality of an institution affects the earnings of graduates but also the probability of graduation[10]. To extend Montmartquette *et al*. (2002), we assume that for an individual *i*, the choice of an institution *j*, is based on the expected probability of graduation (g_j) and expected life time earnings (w_{ij}). We define *A* and *X*, as the determinants of respectively g_j and w_{ij}. The quality of the institution j affects the probability of graduation and earnings upon graduation. Since tuition fees are equal in all institutions, individual *i* expected utility of graduation at an institution *j* is simply:

$$E(U_{ij}) = g_{ij}(A)\, w_{ij}(X) + (1 - g_{ij}(A))\, w_{i0}(X) \qquad (1)$$

[9] These estimates may be considered as a lower bound of the effect of graduating as individuals dropping out of university will in general have lower earnings than college graduates.

[10] The difference in the probability of graduation between institutions reflects variations in the subjects offered and threshold to pass the test. Light and Strayer (2000) for example shows that the probability of graduating is higher when observed ability and quality are matched.

where w_{i0} is the expected lifetime earning of i if dropping out of university. If the supply of places at each university were perfectly elastic, individual *i*, would choose to register at the university maximising the utility of graduation. For an individual with high ability and therefore a high probability of graduation, the choice will mostly be based on expected lifetime earnings; for a less able individual, the probability of graduation may be a more important determinant than the expected earnings.

However, the United Kingdom educational system is centralised and prospective students are limited to applying to only six institutions. Offers are made by the first chosen institution and are conditional on achieving a specific A-level point score. The probability of acceptance to an institution (l_{ij}) is based on the individual characteristics but also on the characteristics of the other applicants at university *j*, say (*Z*). Thus, for individual *i*, the utility of graduation at institution *j* becomes:

$$E(U_{ij}) = l_{ij}(A,Z)\, g_{ij}(A)\, w_{ij}(X) + (1 - l_{ij}(A,Z))\ \mathrm{w}_{i0}(X) + (1 - g_{ij}(A))\, l_{ij}(A,Z)\ \mathrm{w}_{i0}(X) \qquad (2)$$

The second and third terms of the right hand side of (*2*) represent the earnings if not attending tertiary education and the earnings if dropping out of university (respectively). Since, only a limited number of applications are permitted, and individuals may have poor information on the characteristics of other applicants, risk aversion and strategic behaviour affect the mix of institutions applied to. These characteristics of the UK higher education sector create some disparities between the ability of individuals and the institution attended; hence the common support assumption required for out later estimating methods should be fulfilled.

3.2 Econometric issues

The simplest model to estimate the effect on wages of graduating from a particular type of institution is simply to rely on a log wage model (Mincer, 1974) and include dummies for the type of institution attended (Specification 1)[11]. Throughout this discussion, returns are estimated relative to an individual who graduated from a modern university.

$$\ln W_i = I_i b_I + X_i b_X + c + e_i \qquad (3)$$

where for each individual *i*, *ln(W)* is the natural logarithm of gross wage, X_i is a vector of idiosyncratic characteristics affecting wages, *I* refers to the type of institution attended, *c* is a constant for all individuals and ε is an error terms measuring the impact of the non-observable characteristics on the individual wage.

Specification 1 would provide unbiased estimates of institution effects if the matching of candidates and institutions were random. As stated above, the sorting process is mostly based on the A-level scores of prospective students. Therefore, in specification 2, we include the A-level score of the individual. If the matching of students and institutions were solely based on academic ability, then controlling for A-level in the wage regression, would lead to unbiased returns to the type of institution attended. To reflect the heterogeneity in the returns to a degree, we also control for degree class

[11] Since we observed clusters of respondents by institution and institutions are of different size, the standard errors of ordinary least square have to be corrected (Moulton, 1987).

and subject[12] (specification 3). Finally, since prospective students can only apply to a limited number of institutions, some strategic behaviour may be at play. Depending on their risk aversion, expectations about A-level results and competition at a given institution, students may choose a different mix of institutions to apply to. In order to proxy some of the factors affecting the decision process, we include family background, as it may affect risk aversion and the type of schools attended (specification 4), since it may be the case that those attending fee paying schools and other types of secondary level selective institutions have less uncertainty regarding possible A-level scores. These variables would also be correlated with wages, thus, our final specification has the following form.

$$\ln W_i = I_i b_I + X_i b_X + A_i b_A + P_i b_P + S_i b_S + c + e_i \qquad (4)$$

where for each individual i, A is the A-level score achieved and attempts to control for the prior ability of the individual, P is a vector of parental characteristics measured by parental social class and S is the type of school attended prior to university.

The variables to be included in X impact on the estimates. If institutions affect wages directly but also through the sector of work, industry, region or some other observable characteristics that we may want to include in X, the inclusion of these characteristics would reduce our estimates of institutional effects. To capture the total effect of teaching quality on wages, X is restricted to the following covariates: post-graduate qualifications, a quadratic function of labour market experience since graduations, employer size, type of contract (permanent / temporary), self-employment status and current region of residence.

Despite the richness of the dataset, a linear model may still fail to estimate unbiased returns to type of institution attended if the matching process between prospective students and the institution is based on either some non-observable characteristics, or a non-linear function of observable characteristics. A remaining difficulty could be the lack of common support so that institutional effects would not be identified without imposing a functional form.

To explain this last point further, assume that selection is solely based on A-level score (good or average) and that there are only two types of institutions (prestigious, standard). Further, assume that there is no constraint on the number of places available to good students at prestigious institutions. In such a model, all good students would be observed in a prestigious institution and all other students would be in a standard institution. The institutional quality effect would then be perfectly correlated with ability and could not be identified.

To relax the linearity assumption and to make the common support hypothesis explicit, we estimate institutional effects on wages by propensity score matching. In other words, we want to estimate the earning premium for attending a prestigious university compared to a Modern university (Average Treatment Effect on the Treated).

[12] Datcher Loury and Garman (1995) shows that for white omitting major, degree grade and parental income bias upwards the positive effect of college selectivity on earnings by up to 50%.

The probability of graduating from a prestigious institution ($\hat{P}(X_i)$) is calculated for all individuals. In order to be able to match a treated individual at least one individual in the control population must have a "similar" propensity score: this is the common support assumption. As only matched treated individuals are used, it is crucial to check for common support, otherwise, the estimates would be biased[13]. Details on the matching procedure used in this paper are available in the Appendix.

4 Data

Our measure of quality is simply based on the type of institution attended and possible membership of the Russell group[14]. This definition of quality encompasses all the aspects of the institutions that affect the quality of the teaching and the financial returns to their alumni. Therefore, unobservable characteristics such as network effects are also captured. We rely both on the 1985-1990 Graduate Cohort Studies (interviewed in 1996) and the 1995 Graduate Cohort Study (interviewed in 1998). Both surveys contain a representative selection of United Kingdom institutions, which volunteered to survey their alumni by postal survey. The 1985 and 1990 cohorts were both surveyed in 1996, i.e. 6 or 11 years after graduation while the 1995 cohort was surveyed 42 months after graduation. Alumni records may not be adequate for graduates that have left the institution up to 11 years previously, thus the data for the older cohorts may be affected by response bias[15]. The 1998 survey provides some details (DfES, 1999) on response rates, which vary from 16% to 46% by institution, with an average of 27%. Both surveys attempted to create a data set for about 5% of the graduate population but fell somehow short of this target. The raw sample sizes for the 3 cohorts of interest are: 5,835, 9,688 and 10,575 [16].

It should be noted at this stage that although the cohort studies are considered comparable, there are some discrepancies between the data sets which make direct comparisons difficult. In particular, there are differences in the sampling time frame. Therefore, it is impossible to separate a cohort effect from a 'time since graduation' effect. In addition, the information collected on respondents is not directly comparable between cohorts. For instance, information relating to the type of school attended is collected for the 1985 and 1990 cohorts but is not available for the 1995 cohort. Also, 'A' Level score, parental occupation and subject of degree are not defined identically across the two surveys. The main discrepancy between the two surveys concerns the definition of earnings. While both surveys rely on categorical

[13] In case of a lack of common support, the estimate becomes the Average Treatment Effect on the Matched Treated. Heckman et al, (1997) decompose the bias of a propensity score estimate into its three basic components: B_1 is the biased that occurs due to lack of common support, B_2 arises from different distributions of X within the two populations on the common support, and B_3 is due to differences in outcomes that remain even after conditioning on observables and making comparisons on a region of common support (due to selection on the unobservables). The authors compare matching results with experimental data and show that the first two terms of the bias may be substantial.

[14] Heckman *et al*. (1996) suggest that estimates of the effect of quality of education are sensitive to the choice of quality measures and the level of aggregation of the data. Our measure of quality incorporates several dimensions that may or may not be correlated with observable characteristics of the institutions such as peer group or reputation effects.

[15] Additional details can be found in Belfield *et al* (1997, HEFCE research series) who suggest that the survey is broadly representatives of the original student populations

[16] The 1996 survey and the 1998 survey differ slightly in the institutions included in their target population, with the latter survey excluding Open University, a distance learning centre, but also some specialist colleges. To make the cohorts more compatible we exclude Open University graduates from the 1996 survey.

annual gross wage, it is possible to approximate hourly pay for the 1985/1990 cohorts but not for the 1995 cohort, as weekly hours worked are not recorded.

We restrict the working sample to individuals who graduated with an undergraduate degree before the age of 25, who were in full time employment in the UK, provided information on earnings at the time of the survey and were not affected by heath problems limiting their day-to-day activity. These restrictions further reduce the sample size to 2,120, 3,497 and 6,210 observations respectively[17].

To support the assumption of heterogeneity in the population of students between the different types of institutions, Table 3 reports, the mean A-level score by cohort and institution type as well as the proportion of students with no (or missing) A-levels. The analysis is conducted separately by gender but since the conclusions are similar, we only comment on the results relating to women (Panel A). On these two measures the differences between types of institution are significant.

Russell group universities attract more academically able graduates; for all cohorts the average A Level point score reaches 23 out of 30. This is 40% and 50% greater than the average score recorded at Old and Modern universities respectively. The dispersion in the average score is lower for the 1995 cohort than previous cohorts, but this could be due to differences in the measurement of the variable. In particular, for the 1985 and 1990 cohort, the exact score was stated, but for the 1995 cohort only a categorical variable is available. The categorisation hides variations in the distribution of scores between institutions.

There has been an increasing drive to widen participation in higher education through attracting individuals who might not be in possession of traditional university entrance requirements. Using the proportion of graduates without A-levels confirms the differences in the student population. Old and Modern graduates are respectively 2 and 3 times more likely not to possess A-levels than graduates from Russell Group institutions. All institutions have been accepting more and more individuals with alternative qualifications (vocational) and by 1995, 21% of graduates attending a Modern university did not possess A-levels. Men are even more likely to graduate without A-levels, as nearly a third of Modern university graduates did not report having this entrance qualification.

In addition, we also report the distribution of A-level point scores by university type[18] (Table 4). In 1985, a quarter of the graduates from "prestigious" institutions belonged to the top quartile of the ability distribution. This proportion at Modern universities was only 3.5%. Inversely, less than 10% of "prestigious" students originated from the bottom of the A-level score distribution whilst 60% did so at polytechnics. This confirms that students from the different types of institutions are heterogeneous in their ability. This is not surprising since most of the selection process is based on academic ability. However, Table 4 also highlights that this selection is not perfect since all institutions have accepted students from each quartile of the A-level distribution. This provides the first evidence that common support may exist when estimating the effect of graduating from a Russell group institution rather than a Modern university. Black and Smith (2002) find some evidence of asymmetric

[17] The important selection of the sample is due to limiting the population to first degree holders; in the 1996 survey, this restriction eliminates 40% of the surveyed population.
[18] Individuals with no A-level were recoded as 0.

sorting with more able students more likely to be in institutions of lower quality than low ability students in "prestigious" institutions. We do not find such asymmetry despite the fact our sample is more selective (university graduatesrather than those who simply attended university, which, assuming that individuals with lower ability are more likely to drop out of university should lead to greater asymmetry).

Table 5 provides evidence on the earning differential of graduates by type of institution attended. Gross wages are inflated to 2002 prices using the Retail Price Index. For the first two cohorts, we reproduce annual and hourly wage, whilst for the 1995 only the former is reported. Since, all cohorts are surveyed at a different point after graduation, cross cohort comparisons are difficult to interpret.

Graduates from Russell group institutions earn more than those from Modern universities at all points in the income distribution. At the mean, the hourly and annual earnings premium associated with attending a Russell group or an Old university are substantially greater than those associated with attendance at a Modern University. For example, for women graduating in 1985, the average wage following graduation from a Russell group institution is £14.80 (hourly) or £32,686 (annual), which is equivalent to a premium of 19% over graduates from a polytechnic[19].

The premium for attending a "prestigious" institution is of similar magnitude for both genders, around 17% in 1985, 11% in 1990 and between 6% and 9% for the 1995 cohort. The decrease of the premium between cohorts may indicate that the premium for attending a prestigious institution increases with time on the labour market or that the quality gap between institutions has narrowed through time. We will try to differentiate between these two hypotheses in the results section.

The evidence relating to whether there is a premium for attending an Old university is tenuous. At most the difference between graduates from Old and Modern universities reaches 6% for 1995 female graduates, and in a couple of cases these graduates earn less than individuals educated in a Modern university. Graduation from institution categorised as "other" consistently lead to lower earnings but this may be due to the specificity of the degree provided (Teaching qualifications) rather than a quality issue. Additionally, the type of institution does not affect the size of the gender wage gap; for all cohorts and institutions, the gender wage gap is approximately 15%.

This preliminary analysis of the data confirms that attending a "prestigious" institution is correlated with higher earnings but also that students at the different types of institutions are heterogeneous. Importantly for our estimation strategy, the matching of students' ability to university type is not perfect, so a common support should be found.

5 Institutional effects on wages

5.1 Linear selection

First we estimate the model presented in (4). We establish the importance of controlling for pre-university ability (specification 2), subject of graduation and

[19] Since the wage premium for graduating from a prestigious institution is similar for hourly and annual wage, the number of hours worked is not dependent on the type of university attended, at least for this selected group of full-time workers.

grades (specification 3) and parental background (specification 4) compared to a simple Mincer specification with dummies for university type (specification 1). The estimated returns to a degree relative to graduating from a Modern institution are reported separately by cohort and gender in Table 6.

Graduating from a Russell group institution always leads to a wage gain compared to attending a Modern university. In the base specification, this gap ranges from 6 to 16% for women and 9% to 12% for men. The premium for graduating from an Old university is between 0% and 8%, significant only for the most recent cohort. Graduates from "other" institutions fair even less well in the labour market. Results for women are likely to be biased by selection effects, and this selection increases as women ages, thus for cross cohort comparison we focus on men. In this base specification the evolution through time does not reveal major changes in the effect of university quality on graduate wages.

Controlling for pre-university educational achievement (specification 2) reduces the quality premium which becomes insignificant for the 1985 and 1990 cohorts. For the 1995 cohort, adding controls for A-level score reduces the premium associated with attending a Russell group by about 25%. Females from the 1985 cohort are an exception to this rule; the coefficient associated with attending a Russell group university falls only from 16% to 14% with the inclusion of A-level scores. For Old university graduates, the inclusion of academic ability does not have such a substantial effect which highlights the fact that the selection into those universities is not dissimilar to the process conducted in Modern universities.

Adding further controls for subject choice, class of degree achieved and parental background does not substantially affect the estimated quality effects. These results confirm that the selection process is principally based on A-level score. For graduates from "other" institutions, controlling for subject of degree substantially affects their performance compared to graduates from Modern universities. In the simplest model, graduates from institutions classified as "other" appear to benefit less financially from their investment (-6% for women, -10% for men) compared to Modern university attendance. Adding controls for A-levels does not change these conclusions since, as seen in Table 2, the average A Level point score at both types of institutions are similar. However, after controlling for the subject of degree, the financial return to graduating from these institutions is in most cases not substantially different from the return obtained by graduates from Modern universities.

The conclusion of this analysis is that the differences in the returns to a university degree by type of institution attended are, after controlling for ability, subject and family background, less severe than have been claimed elsewhere. In the preferred specification, graduating from a prestigious institution leads to a wage premium ranging between 2% and 17%. Generally, estimates of the returns to the quality or type of HE institution that do no account for pre-university academic ability will lead to results that are heavily biased. Apart from the 1995 cohort, we do not find any quality differences between graduates from Old and Modern universities. These estimates are still biased if there is no common support or the relationship between the observables and earnings does not follow the functional form imposed.

5.2 Propensity score matching

To implement propensity score matching the Conditional Independence Assumption is assumed. The institutional characteristics of the UK application process, makes the claim that selection to a prestigious institution is based on observables plausible Descriptive statistics confirm that the sorting of prospective students to a specific institution is predominantly based on A-level score. Whilst it is crucial that sorting is based on observed characteristics, it is also important that no observed characteristics completely predict access to the treatment group (attendance at a prestigious institution). If sorting on A-levels results was a perfect predictor of the type of university attended, there would be no common support between individuals from different type of institutions and no individual could be paired with an individual (or individuals) from another type of institution.

To estimate the propensity score we use a specification including A-level score, ethnicity and paternal socio-economic group. The 1985 and 1990 cohorts' specification also includes dummies for paternal education, home ownership and type of schools attended, whilst for the 1995 cohort, we add information whether the individual made use of their college career service (more than 4 times) prior to registering at university. These variables attempt to capture academic and financial constraints as well as motivation. All variables are interacted with A-level score. We consider two treatments, attending a Russell group university or an Old university while the control group is composed of graduates from Modern universities[20].

The distributions of propensity scores associated with attendance at a Russell group rather than a Modern university are reported for each cohort and gender in Figure 1. Each bin has a width of 0.05; with the exception of the top bin in the 1995 cohort of men, there is evidence of common support, since for each bin with at least one treated observation there is at least one control observation. This common support is nevertheless rather thin in some cases. The small numbers of available control observations constrains the choice of procedure to matching with replacement. The distributions of propensity scores are remarkably similar by gender. With the expansion of higher education, the selection model becomes less "extreme". For the 1985 cohort, more than 50% of the Russell Group graduates are estimated to have a probability of attending such an institution greater than 95%; this proportion is around 30% for the 1990 cohort and almost nil for the 1995 cohort[21].

This indicates that Russell group universities have 'lowered' their admission standards. The competition for new students also affected the quality of the recruits in Modern universities. Whilst for the 1985 cohort, the distribution of propensity scores is rather uniform, indicating that students of all abilities attended Modern universities, by 1990, about 30% of graduates from former polytechnics possessed a propensity score of attending a prestigious university inferior to 0.05. In other words the competition for students has become more intense. Russell group institutions have effectively poached the most talented pupils away from Modern universities and the growth in the Modern university sector was made possible by attracting students of predominantly lower ability. For example, in 1985, 41% of females in polytechnics

[20] We do not provide matched estimates of the effect of attending an institution classified as "other", as the sample is too small.

[21] It has to be noted that the distribution of the 1995 cohort is affected by the fact that A-level score was reported in a categorical format rather than in a continuous form. Thus, we observed clusters of propensity scores rather than a distribution.

had a propensity of attending a prestigious university lower than 10%. By 1990, this proportion is 57%. The increased competition for students may have had opposite consequences on the relative returns to attending a "prestigious" institution. If Russell Group institutions have lowered their admission standards to a greater extent than modern institution, then the returns to attending a "prestigious" institution should have fallen. If polytechnics have replaced their poached students with students of lower ability, the returns to attending a Russell Group university may have increased

Various matched estimates of institutional effects are reported in Table 7. We also include two indicators of the match quality. First, the proportion of treated observations that are successfully matched (with nearest neighbour) and, as an indicator of the thinness of the common support, we also include the number of control observations accounting for 50% of the matches. This indicates how sensitive our estimates are to the few observations guaranteeing common support. Nearest neighbour matches are reported with a calliper of 0.1 and 0.01. Similarly, kernel estimates use a bandwidth of 0.1 and 0.01. Additionally, to test the linearity assumption, we report OLS results based on the sample of matched pairs with the tightest calliper.

As with the OLS estimates, female graduates from the 1985 cohort enjoy high and stable returns (+16%) above those graduating from Modern universities, however, these estimates are biased due to selection effects For the other cohorts, the estimated effects of graduating from a prestigious institution are much smaller, usually insignificant and far less stable. For all estimates, the common support assumption is validated with the larger calliper and even the tighter calliper leads to match rates above 95%. Therefore, we can be confident, that our estimates are not biased by lack of common support. More worryingly however is that the common support is rather thin, with a handful of control observations being responsible for 50% of the matches[22]. The relative instability and imprecision of our estimates is a direct consequence of this thin support.

Focusing on estimates using Epanechnikov kernel with the tightest bandwidth, attending a prestigious institution leads to a pay premium ranging from 2.5% to 3.7% for women from the 1990 and 1995 cohorts.. Focusing on men, the estimates differ widely by cohort, from 0% in 1985, 4.5% in 1990 and 5.8% in 1995. For all matching procedures, the returns to quality are larger for the younger cohort. While it is impossible to differentiate between a time and a cohort effect, the trend is consistent with an increase in the heterogeneity of the students between institution types, as also observed in the US during a period of increasing participation to higher education.

Quality differs widely in the higher education system in the UK with graduates from the most prestigious universities enjoying substantial pay premium over graduates from Modern institutions. This premium is not precisely estimated due to the thinness of the common support. To test the robustness of these results, we added a normal random error term to the propensity score. While changing the matched pairs and the common support, estimates based on the modified propensity score were similar to those presented. Thus, the thinnest of the common support does not seem to lead to biased results.

[22] Black and Smith (2002) report the distribution of matches and similarly a handful of control observations account for 50% of matches. We are not aware of other studies reporting this measure of the quality of the match.

For each cohort, the last line of Table 7 reports the OLS estimate based on the matched population rather than the full population. The estimates on the selected population are different from those obtained on the full sample, indicating that the original results were affected by the lack of common support. In a number of cases, the matched OLS estimates are out of line with propensity score matching estimates, which indicates that the assumption of linear selection on the observables should be rejected. Previous studies relying on OLS estimating methods may therefore be seriously biased.

Similarly, we estimate the effect of graduating from an Old university as opposed to a Modern university. The distribution of propensity score is reported in Figure 2. As with attending a Russell Group university, we find that with time, the distribution of scores for graduates at Old universities has shifted to the left and looks almost uniform for the 1990 cohort. The distribution for individuals attending a Modern university also shifted to the left, so that the common support assumption is not supported for a few bins.

Nevertheless, Table 8 shows that for all groups, more than 90% of the treated individuals are matched. The common support is almost universal but is rather thin. For most groups, nearest neighbour estimates are lower than kernel based estimates, but within a matching estimator type, the choice of calliper/bandwidth does not significantly alter the estimates. As a consequence of the thin support, the estimates are rather imprecise. As with Russell group institutions, there is no quality premium for older workers and the trends are similar to those previously described. Focusing on kernel match with the tightest bandwidth, there is no clear evidence that graduating from an Old university rather than a Modern university leads to a financial premium and two estimates are even negative. The largest estimates are obtained for the most recent cohort (+4% for women and +2% for men), which is consistent with an improvement in the relative quality of the population of graduates from Old universities. Since, we do not find positive effects of attending an Old university, the remaining of the paper focuses on Russell Group institutions solely.

5.3 Who benefits from attending a "prestigious" institution?

The effect of attending a prestigious institution may be heterogeneous. First, Russell group institutions may vary in quality, this assumption is tested by focusing on two large prestigious universities. The second source of heterogeneity is between students at an institution. The wage gains from attending a prestigious institution may be distributed unevenly between graduates. Does the higher quality of teaching provided benefit students with the highest ability within an institution? Similarly, if we believe that part of the wage premium from attending a prestigious university stems from a network effect then it may be the case that graduates from higher social class reap the benefit while graduates from lower social classes do not benefit as much from the "old boy network".

While the previous results reveal differences between university types, they may hide variations in quality within type. To check this, we isolate two Russell Group institutions for which we have more than 500 observations (grouping the 1985 and 1990 cohorts). For these two institutions, we match graduates following the same procedure as the one presented above with the exception that the propensity score regression also includes cohort and gender dummies as well as their interaction with

A level scores. The common support assumption is easily satisfied as the graduates from both institutions have similar characteristics and only 3 graduates from the better institution (say A)[23] are not matched. In addition, 96 control observations are responsible for 50 % of the matches, with a control observation being used at most in 8 times. Contrary to the generic results, the common support in this case is rather thick. Graduates from institution A earn between 7.5% and 8.5% more than those from the control institution. These estimates are precisely estimated. OLS estimates on the matched population are about 20% lower than nearest neighbour estimate. While the rest of the discussion carries on focusing on differences between institution types, it is worth remembering that differences in quality within institution group (at least for the prestigious group) are also marked

We focus on two observable characteristics of graduates; their ability prior to attending university and their socio-economic background to test the heterogeneity of quality effects among graduates. If the effect on earnings of teaching quality is correlated with ability, this will be informative on how the extra resources are allocated: is the higher quality of teaching focused on a few prestigious students within these prestigious institutions or on the contrary, are the extra resources targeted towards the weaker students? Similarly, the quality effect on earnings may just be due to a reputation or a network effect. As graduates from higher social class may be more able to exploit the network, we test this hypothesis by comparing the pay premium of attending a prestigious institution for high and low socio economic background graduates.

For each individual, we compute the effect of the treatment as the difference between the observed and the control wages (Epanechnikov kernel with bandwidth of 0.01). While there are variations in the income effect associated with attending a Russell Group institution, the effect is neither correlated with ability nor family background. Figure 3 for example plots A-level score and individual treatment effects for females from the 1985 cohort. These results are similar when tested in a parametric set-up[24] or for other cohorts. As no significant correlation between family background and the quality effect is found, we conclude that prestigious institutions provide better quality teaching and that the positive effect of attending them is not solely due to a network effect. Since previous ability has no impact on the quality effect, it seems that prestigious universities allocate their extra resources evenly between their graduates and do not solely focus on a few prominent students.

In other words, while Russell Group institutions are rather unequal in their current access arrangements, with more able pupils from better socio-economic background being over-represented. The positive earning effect of attending a prestigious institution is independent of the student's characteristics so these institutions appear to level the playing field within their intake. The effect of institution on earnings stems from differences in the quality of the teaching rather than solely on network effect. This may explain why heterogeneity between institutions is large. Comparing two Russell group universities, graduates from the most prestigious earn 6% more than the others.

[23] Institutions can be identified but not named.

[24] Ordinary least square of the determinants of treatment effects were estimated separately for each cohort and gender. The specification was similar to the one used for estimating wages. The coefficients on A-level score and paternal occupation were not found significant.

5.4 Wage growth effects

The premium for attending a prestigious institution may have various origins. Theoretically, three explanations can be advanced. Better educational quality improves the human capital of students, hence at each period of their life, graduates from more prestigious universities earn more than others, however, the human capital model should not be associated with differences in the earning growth of the two types of graduates. The other two hypotheses have conflicting predictions regarding relative wage growth of graduates from prestigious universities. In a signalling model, the prestige of an institution may be used by employers to differentiate between new graduates when hiring. With time, the true ability of individuals will be revealed and the value of the signal will tend to zero. In such a world, the premium for attending a prestigious institution diminishes over time in the labour market and graduates from different types of institution should achieve similar wage growth. An alternative hypothesis is that if part of the returns to attending a prestigious institution consists in peer group effects, one may expect the returns to the peer group to increase with time on the labour market. In an "old boy network" world, the wage growth of Russell Group graduates should be higher than the one expected by graduates from Modern universities. Thus, looking at wage growth allows us to conjecture on the origin of the pay gap between graduates from different types of institutions.

The 1996 survey of graduates reports annual earnings one, six and, for the 1985 cohort of graduates, 11 years after graduation. For individuals with positive earnings in both periods, we calculate wage growth[25]. The earning profile of UK graduates is steep, with a mean growth ranging from 60% to 100% for the period between the first and sixth year following graduation[26]. Confirming the human capital model, wage growth decreases with labour market experience and is reduced by about half for the second period (6 to 11 years after graduation). Individuals graduating from prestigious institutions have higher earnings growth but for most groups the differences are not significant. The institutional gap is larger for the younger cohort; indicating that for the younger cohort, the populations graduating from Russell and Modern universities are less substitutable than they were for the 1985 cohort. Gender differences in earning growth are limited, which is largely due to the selectivity of our sample.

Individuals are matched on the propensity of graduating from a Russell Group institution following the same specification as the one detailed in the section on earnings effects. In Table 9, estimates obtained by propensity score matching using nearest neighbour and a calliper of 0.1 and using Epanechnikov kernel with a bandwidth of 0.1, are presented separately by sex, cohort and time period. For most groups, kernel matching produces more precisely defined estimates, so we concentrate the discussion on this set of results. The precision of the estimates is affected by the thinness of the common support.

Female graduates from Russell Group universities enjoy substantially higher earning growth compared with their peers who graduated from a Modern university (15

[25] The earnings variables are categorical, and mid-points are used to calculate earning growth which leads to mis-measurement of the true earning growth. Individuals reporting earnings in the same bin at two points are estimated to have experienced negative growth due to the deflation of the mid-point value over-time. However, only 1% of the individuals remain in the same earning category between 1986 and 1991, and 3% between 1991 and 1996.

[26] These estimates of wage growth are affected by selection, since only individuals reporting earnings in the two periods are selected.

percentage points over the period between the first and sixth years for the 1990 cohort). For the 1985 cohort, the growth gap decreases over time but remains substantial and significant. Results for women may be severely biased by selection in the labour market. Focusing on men, the estimates bounce depending on the matching procedure used. In most cases, no effect of quality on wage growth is found. It seems that the human capital of graduates is permanently increased by attending a prestigious institution.

6 Fee differentials

Armed with the evidence that for some groups, graduating from a more selective institution leads to higher earnings and potentially higher wage growth, we now crudely estimate under simplistic assumptions the tuition fee that a representative individual entering a Russell Group institution would be willing to pay over and above those charged at a Modern university in order to capture this earnings differential. First, using the Labour Force Survey, we estimate an age earnings profile of university graduates compared to those in possession of GCE A levels as their highest qualification and adjust earnings according to the premium associated with Russell Group attendance estimated in the previous section[27]. We also assume that the likelihood of employment is the same for all graduates, irrespective of the institution attended. Based on a real earnings growth rate of 2.0% and a real discount rate of 3.5% (both HM Treasury current official figures) and the current tax allowance and rates, we calculate the difference in the net present value of the lifetime earnings of graduates from Modern and Russell Group universities.

We build four scenarios; in the first two, graduates from Russell Group universities enjoy a premium over other graduates in every period of their working lives (assumed to be between age 21 and 60). This premium is fixed at 2% in scenario 1 and 5% in the scenario 2. Scenarios 3 and 4 are based on the opposite hypotheses that the premium respectively increases and decreases though time. Scenario 3 is consistent with a network effect, where Russell group graduates earnings growth increases though time, while scenario 4 is in line with a signalling model, where as the employers discover the true ability of graduates, the signal attached with graduating from a Russell Group university diminishes over time.

We calculate the difference in the net present value of attending a Russell Group University and a Modern University under the various scenarios. Assuming that a degree takes three years to complete, we convert these net present values to a measure of 'willingness to pay'. In other words, we estimate what a representative individual graduating from a Russell Group University would be prepared to pay in tuition fees per annum over and above that fee which might be paid by an individual attending a Modern university. The results are presented in Table 10.

Our calculations of the annual fee differential range from £2,950 to £7,250 under these various scenarios. Since no strong support for quality effect on wage growth was found, scenario 1 and 2 may reflect evolution of graduate wages more appropriately. The UK government is currently planning to allow all universities to charge fees up to £3,000 per annum. So if we believe that the market for higher

[27] As the Labour Force Survey includes graduates from various type of institution, the mean graduate premium estimated is an upward value of the returns to graduating from a polytechnic, which would bias our estimates of the fee differential upwards.

education can reach an equilibrium, Russell Group universities should set their fees at this new maximum, while less prestigious institution may be tempted by reducing their fees (currently set at £1,100) in order to attract more students. Our estimates of fee differentials do not appear to be out of line with such a scenario. In order to capture a life-time earning premium, graduates from prestigious universities should be ready to pay tuition fees of ranging from £3,000 to £7,000 per annum more than the fees charged by Modern universities. Even allowing fees to increase to £3,000 will under most scenarios, mean that students do not fully pay for the financial premium associated with graduating from a more prestigious institution. Students attending prestigious institutions are therefore more subsidised than their peers graduating from less prestigious universities.

In the US, where a linear relationship between tuition and quality is more likely to exist (Daniel *et al.*, 1997), annual tuition and required fees at the 25th and 75th percentiles for the academic year 2000/2001 were respectively $2,594 and $4,094 in the public sector and $11,550 and $19,400 in private institutions[28]. The inter-quartile range is therefore (in 2002 pounds) £1,000 in the public sector and £5,000 for private institutions. Despite the simplistic assumptions used to construct our estimates of fee differentials between institution types, it appears that our calculations are also in line with US evidence, where the providers of higher education are free to set their price[29].

Finally, despite the unique price charged in higher education, institutions have some freedom to allocate their budget. Comparing cost differential and return differentials is informative of the relative efficiency of the different types of institutions[30]. Only institutions with more than 1,000 undergraduate students are used for the calculations of the median academic expenditures per student. Russell group institutions spend £4,000 more on their academic expenditure per student compared to Modern universities. This may be seen as the cost of providing higher quality teaching to their undergraduates compared to Modern universities. Assuming a permanent effect of university quality on wages, the extra teaching cost can be recouped if a wage premium of 2.8% is obtained by their graduates. A larger premium will indicate that Russell group institutions are more efficient providers of higher education. Since our matching estimates of the quality effect are imprecise, we cannot make any firm conclusion regarding the relative efficiency of the institutions.

7 Conclusions

This paper attempts to inform the debate on higher education tuition fees in the UK. This debate was initiated by the most prestigious institutions claiming that since they provide a service of higher quality teaching to their graduates, as measured by their earnings and the cost of provision, they should be allowed to charge higher tuition fees. This claim of heterogeneity in the returns to higher education by type of institution is nevertheless controversial as the intake of the various institutions is dissimilar.

[28] Fees were obtained from the National Center for Education Statistics website. For public institution no break down by in or out of state residency status was available.

[29] Contrary to Daniel *et al* (1997), Sweetman (1995) find that despite the freedom to set tuition fees, the premium for attending a prestigious college is larger than the fee differential.

[30] Differences in academic expenditures are a crude measure of the relative efficiency of the different institutions. First, considering the institutional set-up, it is unclear how these differences originate. Second, expenditures on academic department are only one component of the quality of the teaching at a given institution.

The matching of students to an institution's quality is largely put not perfectly due to academic ability. This imperfect sorting may be due to some institutional features and provides an estimation strategy: students at prestigious institutions can be paired with "similar" students in less prestigious universities. This strategy assumes that selection into the different types of university is based on observable characteristics, mostly academic achievements, but does not impose a functional form for the relationship between these observables and the choice of an institution. In fact, our results based on three cohorts of UK graduates point out that estimates based on ordinary least square could be substantially biased due to the linearity constraint.

Propensity score matching estimates are affected by the thinness of the common support and tend to be imprecise. After controlling for academic achievement, subject of degree and family background, the quality claim has been largely over-stated. Attending a Russell Group institution (compared to a Modern university) leads to an earning premium ranging from 0 to 6% for men. Estimates for women are biased by selection effects. For the younger cohort, however, a premium of 2.5% is estimated.

The financial benefit of attending a Russell Group university is homogenous, and is neither dependent on previous academic achievement nor parental background. In some sense, these universities level the playing field for their graduates. However, heterogeneity between prestigious institutions is large. We find that the increase in earnings derived by graduates from prestigious universities stems from an increase in human capital rather than signalling or network effect, as it appears to be constant over time.

Finally, we use these estimates of the returns to the type of institution attended to predict prices in the higher education market if institutions were left with the freedom to set their tuition fees. Under various scenarios, we estimate a fee differential between Russell Group and Modern universities ranging from £3,000 to £7,000. This range of tuition fees is in line with the current inter-quartile range observed in the US among private institutions. A tuition fee differential of £4,000 is also in line with measures of the differences in academic expenditures between the two types of institutions. These results suggest that by implementing a unique price of higher education (the current practice), the government subsidises graduates attending more prestigious institutions more generously than others and that as such there is some justification in the claim that institutions should be allowed greater freedom in setting their tuition fees.

However, introducing price competition will drastically affect higher education in the UK. As mentioned in the current White Paper (HMO, 2003), with the introduction of fee differentials, students are going to become more exigent customers. Thus while average quality is likely to increase, the heterogeneity between institutions may also augment with some institutions deciding to compete on lower price and others on higher quality (and the associated perceptions). The choice of subject provided by universities may also be affected with less popular courses being dropped out in favour of high revenue courses. Hoxby (1997) demonstrates that these market mechanisms took place in the US and are responsible for higher average quality, a homogenisation of the students within institutions and a greater variation in the quality of the degree provided between institutions. This is already happening in the UK. A negative consequence of the increased competition between providers of tertiary education is therefore to make the signal attached to a degree fuzzier or less

precise to employers. Hoxby and Terry (1999) note that variations in the returns to college education have significantly increased in the US as the education systems became more market oriented. The authors also show that the increasing matching of students' ability to college quality is responsible for 40% of the explained growth in the dispersion of returns to higher education. A policy of liberalising prices of higher education in the UK may end up having similar effects.

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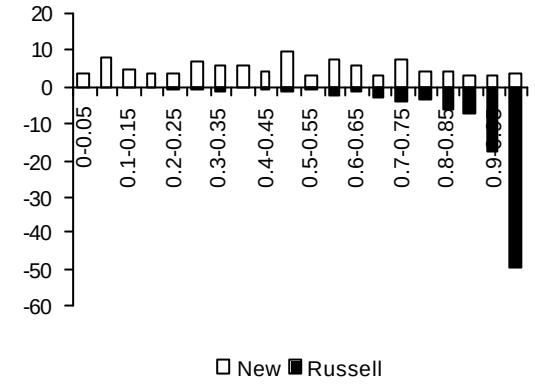
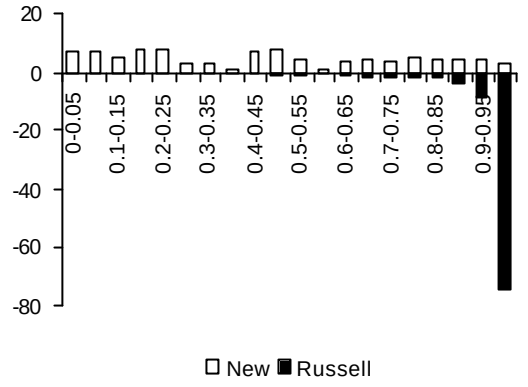
Figure 1: Distribution of propensity scores between Russell Group and Modern Universities.

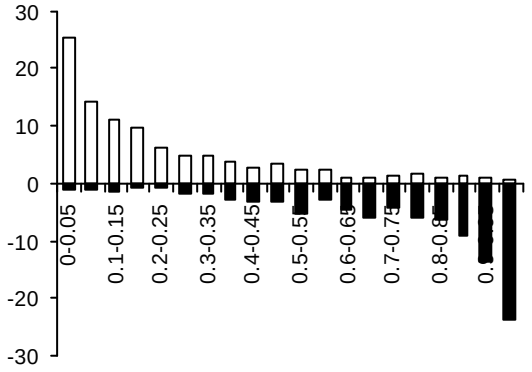
Female, 1985 Cohort



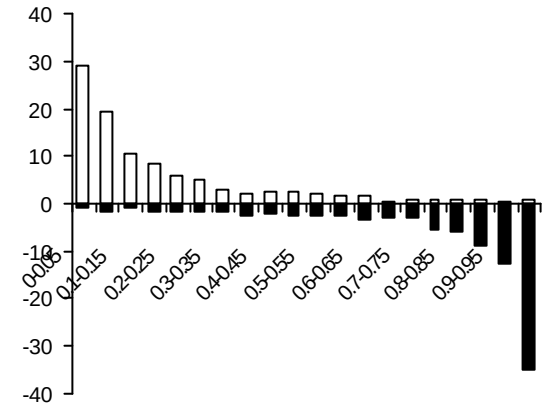
Male, 1985 Cohort



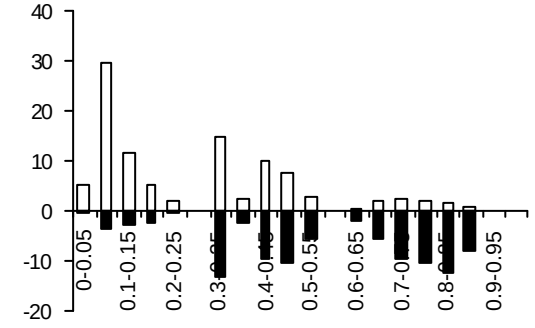
Female, 1990 Cohort



Male, 1990 Cohort



Female, 1995 Cohort



Male, 1995 Cohort

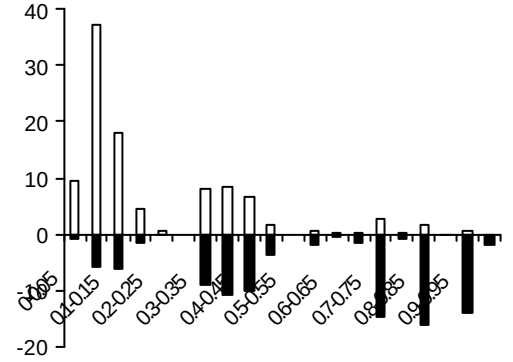
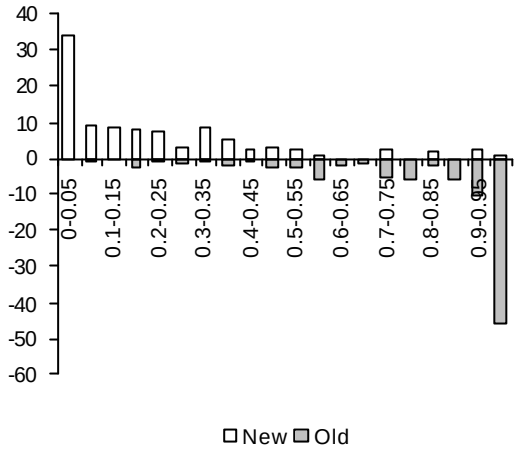
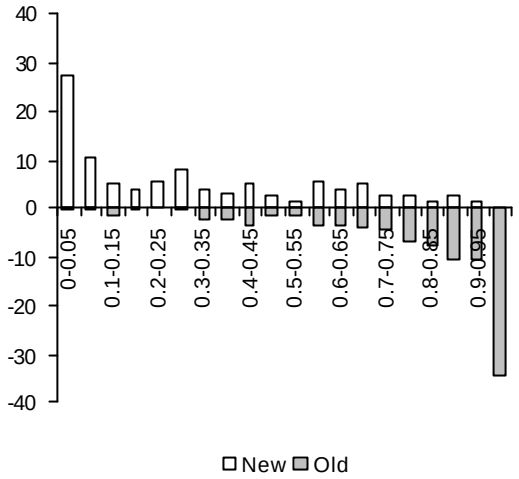


Figure 2: Distribution of propensity score between Old and Modern Universities.

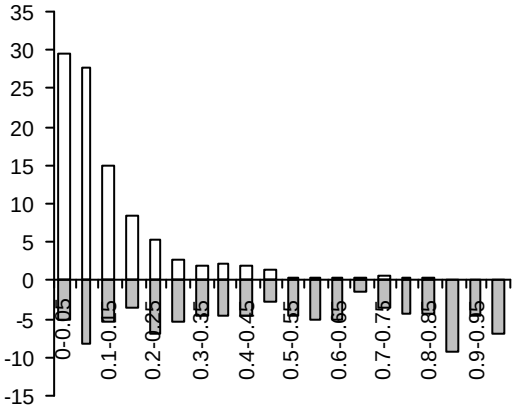
Female, 1985 Cohort



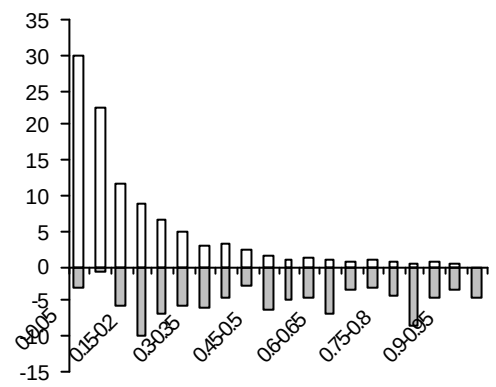
Male, 1985 Cohort



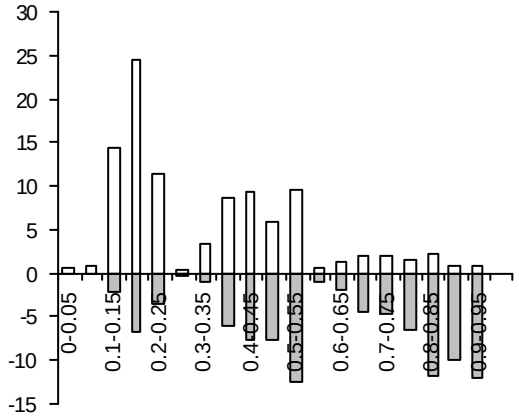
Female, 1990 Cohort



Male, 1990 Cohort



Female 1995 Cohort



Male: 1995 Cohort

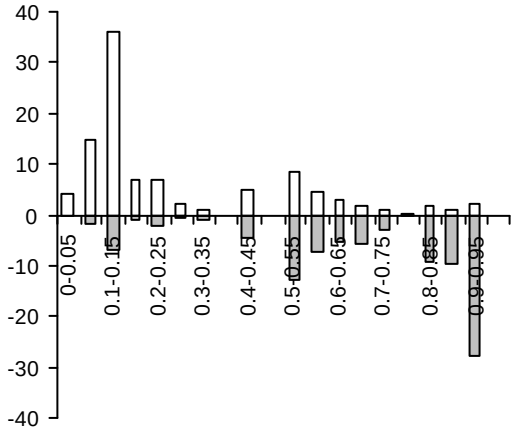
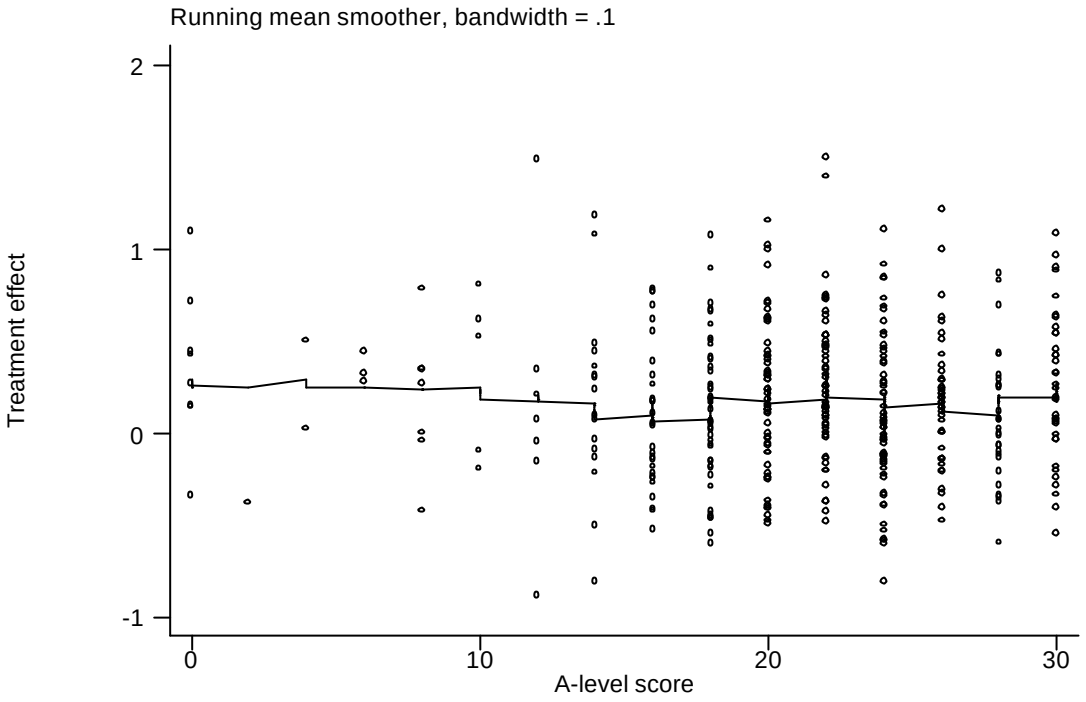


Figure 3: A-level score and wage premium of attending a Russell Group University over a Modern University: Women, Cohort 1985



Note: Wage differential estimated by propensity score matching (Epanechnikov, bandwidth=0.01)

Table 1: Age Participation Index by Social Class
(Entrants who are GB domiciled, full-time, undergraduates aged less than 21 as a proportion of the average of 18 and 19 year old population)

	1940	1950	1960	1970	1980	1990	2000
Overall API	1.8	3.4	5.4	8.4	12.4	19.3	33.4
Top 3 social classes	8.4	18.5	26.7	32.4	33.1	36.7	47.8
Bottom 3 social classes	1.5	2.7	3.6	5.1	6.5	10.3	18.2
Social Class Gap	6.6	15.8	23.1	27.3	26.6	26.4	29.6

Source: HMO, Department for Education and Skills, 2003

Table 2: Distribution of A-levels scores by Institution Type

Panel A: Women

	Russell Group Universities	Old Universities	Modern Universities	Other Institutions
1985 Cohort				
No A-levels	0.017	0.040	0.063	0
Mean A-level score	22.87	16.47	14.10	12.57
(out of 30)	(5.48)	(6.20)	(6.45)	(6.99)
Observations	531	149	143	28
1990 Cohort				
No A-level	0.020	0.041	0.069	0.030
Mean A-level score	23.08	17.92	13.98	11.85
(out of 30)	(4.88)	(6.07)	(5.76)	(6.67)
Observations	681	197	766	132
1995 Cohort				
No A-level	0.060	0.078	0.211	0.072
Mean A-level score	23.13	22.47	18.05	17.57
(out of 30)	(3.95)	(4.13)	(4.11)	(4.43)
Observations	757	1083	1263	426

Panel B: Men

	Russell Group Universities	Old Universities	Modern Universities	Other Institutions
1985 Cohort				
No A-level	0.024	0.071	0.079	0.091
Mean A-level score	23.59	17.83	14.00	20.20
(out of 30)	(5.14)	(6.22)	(6.34)	(9.88)
Observations	883	237	127	22
1990 Cohort				
No A-level	0.016	0.118	0.149	0.079
Mean A-level score	24.32	19.97	14.21	14.14
(out of 30)	(4.80)	(5.84)	(6.10)	(7.81)
Observations	663	220	752	76
1995 Cohort				
No A-level	0.069	0.080	0.303	0.098
Mean A-level score	22.71	22.84	17.00	17.44
(out of 30)	(4.29)	(4.04)	(3.84)	(3.94)
Observations	515	902	1143	121

Note: 1995 cohort A level results are reported in a categorical variable, we used category mid-points. The mean A-level is based on individuals with a positive score.

Table 3: Bivariate distribution of ability by Institution Type

Panel A: Women

	Russell Group Universities	Old Universities	Modern Universities	Other Institutions
1985 Cohort				
Quartile 1	9.42	44.97	59.44	67.86
Quartile 2	25.61	30.87	26.57	17.86
Quartile 3	39.74	19.46	10.49	14.29
Quartile 4	25.24	4.70	3.50	-
Observations	531	149	143	28
1990 Cohort				
Quartile 1	4.99	25.89	51.31	68.94
Quartile 2	15.27	32.99	32.77	17.42
Quartile 3	41.41	29.44	10.97	6.82
Quartile 4	38.33	11.68	4.96	6.82
Observations	681	197	766	132
1995 Cohort				
Quartile 1	6.01	7.80	21.11	7.24
Quartile 2	4.24	6.93	34.73	51.12
Quartile 3	44.15	46.78	36.34	30.45
Quartile 4	45.60	38.49	7.82	11.19
Observations	757	1083	1263	426

Panel B: Men

	Russell Group Universities	Old Universities	Modern Universities	Other Institutions
1985 Cohort				
Quartile 1	12.91	45.99	74.02	36.36
Quartile 2	29.67	35.02	17.32	9.09
Quartile 3	27.63	10.97	4.72	22.73
Quartile 4	29.78	8.02	3.94	31.82
Observations	883	237	127	22
1990 Cohort				
Quartile 1	3.47	23.18	54.39	61.84
Quartile 2	12.22	27.73	26.73	14.47
Quartile 3	34.99	30.00	14.76	10.53
Quartile 4	49.32	19.09	4.12	13.116
Observations	663	220	752	76
1995 Cohort				
Quartile 1	6.92	8.02	30.31	9.80
Quartile 2	8.08	5.36	39.96	46.16
Quartile 3	41.94	44.68	25.36	37.36
Quartile 4	43.06	41.94	4.37	6.68
Observations	515	902	1143	121

Note: 1995 cohort A level results are reported in a categorical variable, which are used rather than quartile. Individuals with no A-levels are coded as having a score of 0

Table 4: Distribution of hourly and annual pay (in 2002 price) by institution type

Panel A: Women	**Russell Group Universities**		**Old Universities**		**Modern Universities**		**Other Institutions**	
1985 Cohort	Hourly pay	Annual wage	Hourly pay	Annual wage	Hourly pay	Annual wage	Hourly pay	Annual wage
10th percentile	9.13	19,002	7.66	15,547	7.31	15,547	5.98	15,547
50th percentile	13.53	28,215	11.90	24,760	11.90	24,760	9.87	23,320
90th percentile	22.15	51,823	18.76	43,186	18.46	38,580	18.08	43,186
Mean	14.80	32,686	12.73	27,751	12.44	27,438	11.85	26,488
	(5.67)	(13,616)	(5.60)	(12,271)	(4.87)	(11,596)	(6.57)	(14,252)
Observations	531		149		143		28	
1990 Cohort								
10th percentile	7.30	15,547	6.09	15,547	6.64	15,547	6.58	15,547
50th percentile	10.52	21,881	9.62	21,881	9.88	21,881	8.79	21,881
90th percentile	16.46	35,124	14.00	28,215	13.60	31,670	12.38	28,215
Mean	11.37	25,100	10.19	21,887	10.33	22,648	9.45	21,837
	(4.44)	(10,262)	(3.84)	(7,986)	(3.62)	(7,897)	(3.24)	(8,089)
Observations	681		197		766		132	
1995 Cohort	Annual wage		Annual wage		Annual wage		Annual wage	
10th percentile	11,839		11,839		11,839		11,839	
50th percentile	17,760		17,760		17,760		17,760	
90th percentile	30,676		27,447		27,447		24,218	
Mean	19,860		19,878		18,810		17,330	
	(7,627)		(7,458)		(6,778)		(5,731)	
Observations	740		1058		1233		418	

Panel B: Men	**Russell Group Universities**		**Old Universities**		**Modern Universities**		**Other Institutions**	
1985 Cohort	Hourly pay	Annual wage	Hourly pay	Annual wage	Hourly pay	Annual wage	Hourly pay	Annual wage
10th percentile	9.86	24,760	8.12	19,000	9.34	21,881	9.52	24,760
50th percentile	16.03	35,125	12.99	28,215	13.56	31,670	13.88	43,186
90th percentile	26.58	69,098	22.15	51,823	22.15	69,098	21.78	69,098
Mean	16.93	39,659	14.20	32,668	14.60	35,011	15.39	26,488
	(6.38)	(15,443)	(5.87)	(13,716)	(5.26)	(15,035)	(5.83)	(14,253)
Observations	883		237		127		22	
1990 Cohort								
10th percentile	7.47	15,547	6.96	15,547	6.77	15,547	6.53	15,547
50th percentile	11.90	24,760	10.98	24,760	10.58	24,760	9.14	21,881
90th percentile	18.46	43,186	16.00	35,125	15.71	35,125	13.56	35,125
Mean	12.64	29,220	11.78	26,574	11.29	25,564	9.78	23,578
	(4.99)	(12,425)	(5.14)	(11,541)	(4.40)	(9,912)	(3.20)	(9,039)
Observations	663		220		752		76	
1995 Cohort	Annual wage		Annual wage		Annual wage		Annual wage	
10th percentile	14,531		14,531		11,839		11,839	
50th percentile	20,989		20,989		20,989		17,560	
90th percentile	37,134		33,905		30,676		27,447	
Mean	23,962		22,706		21,908		18,220	
	(9,679)		(9,329)		(8,588)		(6,170)	
Observations	502		870		1116		113	

Note: Gross wages are expressed in GBP (price 2002). For all cohorts, annual gross wage is reported in categorical form

Table 5: Linear estimates of institutional effects on gross wage

Panel A: Women	Specification (1)	Specification (2)	Specification (3)	Specification (4)
1985 Cohort				
RG University	0.163 (5.45)	0.141 (4.30)	0.172 (4.39)	0.168 (4.40)
Old University	0.043 (0.82)	0.034 (0.66)	0.055 (1.07)	0.060 (1.14)
Other Institution	-0.061 (0.73)	-0.058 (0.70)	-0.009 (0.09)	0.003 (0.03)
R^2	0.29	0.29	0.32	0.33
1990 Cohort				
RG University	0.063 (3.55)	0.025 (1.52)	0.032 (1.59)	0.025 (1.20)
Old University	-0.002 (0.05)	-0.023 (0.60)	-0.024 (0.81)	-0.029 (0.99)
Other Institution	-0.056 (3.53)	-0.050 (3.15)	-0.039 (2.27)	-0.044 (2.54)
R^2	0.22	0.23	0.26	0.27
1995 Cohort				
RG University	0.081 (2.53)	0.062 (1.71)	0.062 (2.26)	0.058 (2.11)
Old University	0.083 (3.35)	0.066 (2.37)	0.082 (3.14)	0.077 (2.96)
Other Institution	-0.059 (2.57)	-0.066 (2.66)	-0.020 (0.78)	-0.018 (0.70)
R^2	0.20	0.20	0.26	0.26
Panel B: Men	Specification (1)	Specification (2)	Specification (3)	Specification (4)
1985 Cohort				
RG University	0.111 (4.21)	0.038 (1.61)	0.052 (1.83)	0.047 (1.64)
Old University	0.027 (0.96)	-0.010 (0.33)	0.003 (0.10)	0.004 (0.13)
Other Institution	-0.050 (0.52)	-0.093 (1.38)	-0.136 (2.43)	-0.133 (2.42)
R^2	0.30	0.32	0.36	0.36
1990 Cohort				
RG University	0.091 (3.76)	0.046 (1.44)	0.049 (1.39)	0.044 (1.27)
Old University	0.071 (1.56)	0.044 (1.02)	0.033 (0.93)	0.032 (0.94)
Other Institution	-0.141 (3.35)	-0.144 (3.99)	-0.117 (3.65)	-0.120 (3.86)
R^2	0.27	0.27	0.32	0.33
1995 Cohort				
RG University	0.124 (3.97)	0.111 (3.12)	0.101 (3.25)	0.094 (3.10)
Old University	0.084 (3.02)	0.071 (2.25)	0.070 (2.36)	0.064 (2.28)
Other Institution	-0.100 (1.96)	-0.096 (1.89)	-0.031 (0.62)	-0.031 (0.64)
R^2	0.25	0.25	0.31	0.32

Note: Hourly wages are used for the 1985 and the 1990 cohort. Model (1) controls for a quadratic function in labour market experience, firm size, type of contract self-employment, race, region of residence and post-graduate qualifications. In Model (2) we add A-level scores. Model (3) is similar to (2) but also includes subject of graduation and degree grade. The full model (4) adds controls for type of school attended (cohort 1985 and 1990) or visit to information services (cohort 1995) and father's occupation. T-statistics are reported in parentheses.

Table 6: Matching estimates of graduating from a Russell Group institution on gross wage

	Women		Men	
	Estimate	% matched[A] (50%)[B] Obs[C]	Estimate	% matched[A] (50%)[B] Obs[C]
1985 Cohort				
Nearest Neighbour Cal 0.1	0.155 (0.116)	100% (4)	-0.007 (0.093)	100% (5)
Kernel Epan. Band 0.1	0.170 (0.056)	531	0.058 (0.066)	883
Nearest Neighbour Cal 0.01	0.158 (0.097)	86% (6)	-0.006 (0.098)	96% (6)
Kernel Epan. Band 0.01	0.170 (0.064)	459	0.009 (0.070)	846
OLS on matched sample	0.215 (0.050)	N=535 R^2=0.08	0.025 (0.050)	N=920 R^2=0.08
1990 Cohort				
Nearest Neighbour Cal 0.1	0.051 (0.037)	100% (25)	0.070 (0.064)	100% (14)
Kernel Epan. Band 0.1	0.021 (0.030)	681	0.032 (0.029_	663
Nearest Neighbour Cal 0.01	0.053 (0.038)	99% (26)	0.066 (0.068)	93% (17)
Kernel Epan. Band 0.01	0.037 (0.033)	674	0.045 (0.031)	618
OLS on matched sample	0.066 (0.031)	N=858 R^2=0.08	0.056 (0.035)	N=785 R^2=0.10
1995 Cohort				
Nearest Neighbour Cal 0.1	-0.014 (0.112)	100% (8)	0.151 (0.076)	100% (9)
Kernel Epan. Band 0.1	0.037 (0.028)	740	0.069 (0.039)	502
Nearest Neighbour Cal 0.01	0.079 (0.090)	98% (8)	-0.017 (0.092)	98% (9)
Kernel Epan. Band 0.01	0.024 (0.029)	724	0.058 (0.038)	491
OLS on matched sample	0.001 (0.034)	N=785 R^2=0.31	0.108 (0.065)	N=545 R^2=0.39

Note: The comparison group is drowned out of graduates from New Universities. Standard error calculated by bootstrap (500 replications). OLS uses the full control specification on the population of matched treated and control observations. Kernel estimates are obtained using Epanechnikov kernel.

[A] Percentage of treated observations matched to a control observation (nearest neighbour)

[B] Number of control observations responsible for 50% of the matches.

[C] Number of treated observations

Table 7: Matching estimates of graduating from an old university on gross wage

	Women		Men	
	Estimates	% matched[A] (50%)[B] Obs[C]	Estimates	% matched[A] (50%)[B] Obs[C]
1985 Cohort				
Nearest Neighbour Cal 0.1	-0.017 (0.066)	92% (13)	-0.005 (0.070)	100% (13)
Kernel Epan. Band 0.1	0.012 (0.055)	138	-0.088 (0.053)	237
Nearest Neighbour Cal 0.05	-0.016 (0.066)	91% (13)	-0.017 (0.066)	97% (14)
Kernel Epan. Band 0.05	0.004 (0.058)	137	-0.076 (0.057)	230
OLS on matched sample	-0.038 (0.058)	N=201 R^2=0.10	-0.055 (0.054)	N=301 R^2=0.116
1990 Cohort				
Nearest Neighbour Cal 0.1	-0.123 (0.036)	100% (41)	-0.001 (0.039)	99.6% (37)
Kernel Epan. Band 0.1	-0.061 (0.029)	197	0.025 (0.031)	219
Nearest Neighbour Cal 0.05	-0.110 (0.036)	99% (41)	0.002 (0.041)	98.6% (38)
Kernel Epan. Band 0.05	-0.065 (0.029)	195	0.020 (0.032)	217
OLS on matched sample	-0.095 (0.037)	N=330 R^2=0.08	0.010 (0.037)	N=357 R^2=0.133
1995 Cohort				
Nearest Neighbour Cal 0.1	-0.023 (0.088)	100% (9)	0.075 (0.090)	100% (8)
Kernel Epan. Band 0.1	0.053 (0.027)	1058	0.039 (0.035)	870
Nearest Neighbour Cal 0.01	-0.037 (0.080)	98% (8)	0.089 (0.108)	99% (8)
Kernel Epan. Band 0.01	0.042 (0.027)	1039	0.021 (0.037)	865
OLS on matched sample	0.035 (0.042)	N=1095 R^2=0.33	0.073 (0.055)	N=925 R^2=0.35

Note: The comparison group is drowned out of graduates from New Universities. Standard error calculated by bootstrap (500 replications). OLS uses the full control specification on the population of matched treated and control observations. Kernel estimates are obtained using Epanechnikov kernel.
[A] Percentage of treated observations matched to a control observation (nearest neighbour)
[B] Number of control observations responsible for 50% of the matches.
[C] Number of treated observations

Table 8: Matching estimates of graduating from a Russell Group institution on wage growth

	Women		Men	
	Estimate	% matched[A] (50%)[B] Obs[C]	Estimate	% matched[A] (50%)[B] Obs[C]
1985 Cohort				
Growth 1986-1991				
Nearest Neighbour Cal 0.1	0.302 (.510)	100% (4)	0.037 (0.316)	100% (5)
Kernel Epan. Band 0.1	0.234 (0.192)	343	0.292 (0.117)	682
Growth 1991-1996				
Nearest Neighbour Cal 0.1	0.164 (0.121)	100% (5)	0.047 (0.117)	100% (5)
Kernel Epan. Band 0.1	0.157 (0.068)	486	0.001 (0.083)	834
1990 Cohort				
Growth 1991-1996				
Nearest Neighbour Cal 0.1	0.208 (0.106)	100% (20)	0.071 (0.180)	100% (15)
Kernel Epan. Band 0.1	0.147 (0.082)	464	0.031 (0.128)	462

Note: The comparison group is drowned out of graduates from New Universities. Standard error calculated by bootstrap (500 replications). Kernel estimates are obtained using Epanechnikov kernel.
[A] Percentage of treated observations matched to a control observation (nearest neighbour)
[B] Number of control observations responsible for 50% of the matches.
[C] Number of treated observations

Table 9: Annual fee differentials between graduates from Russell group institution and other graduates.

	Annual fee differential
Scenario 1: + 2% over life-time	£2,950
Scenario 2: + 5% over life-time	£7,100
Scenario 3: increasing differential[1]	£4,750
Scenario 3: decreasing differential[2]	£7,250

Note: Calculations based on LFS (2002) in GBP, 2002 prices
[1]The pay differential of Russell group graduates over other graduates are 0%, 2%, 5% and 10% respectively over the following age groups: 21-30, 31-40, 41-50 and 51-60.
[2]The pay differential of Russell group graduates over other graduates are 10%, 5% and 2% respectively over the following age groups: 21-30, 31-40, 41-50 and zero thereafter.

Appendix: Current University funding arrangements

At present, the Higher Education Funding Council for England (HEFCE) distributes funding from central government to Higher Education Institutions in England and Wales according to the research and teaching these institutions undertake.

Teaching resources are allocated according to the number of full time students (and part time equivalent), however, there are several criteria for receiving additional funds depending on the subjects provided ('clinical stage of medicine, dentistry and veterinary science', 'laboratory based subjects', 'subjects with a laboratory components' and 'other subjects'); the type of student ('mature', 'part time' and 'students on long courses'); and the institution ('London premium', 'pensions', 'specialist institutions' and 'old and historic buildings')

In addition to the funds for teaching, universities are eligible for research grants based on the 5 yearly Research Assessment Exercise (RAE). There are three components of quality related research (QR) as follows: Mainstream QR (allocated to reflect the quality and volume of research at institutions in different subjects); Funds for supervision of research students and London weighting (allocated to reflect the additional costs of provision in London)

Mainstream QR funds are weighted according to the field of study ('high cost laboratory and clinical subjects', 'intermediate cost subjects' and 'Others') and adjusted according to the number of research active staff, the number of research fellows, research assistants, postgraduate research students and research income from charities. The number of research active staff is far and away the most important measure of volume.

The quality of research is rated according to a scale ranging between 1 (worst) and 5* (best), which has funding weights associated with each score. The measure of volume and quality are the multiplied to calculate the allocation of resources to each institution.

Appendix: Propensity score matching

We introduce the following notation: Y_1 and Y_0 are the earnings associated with graduation from a prestigious and a standard institution respectively. D is a dichotomous variable taking the value one for individual graduating from a prestigious institution (treatment).

$$ATET = E(Y_1 - Y_0 / X, D = 1) = E(Y_1 / X, D = 1) - E(Y_0 / X, D = 1) \qquad \text{(A1)}$$

As individuals are observed in only one state of the treatment, $E(Y_0 / X, D = 1)$ is never observed. In order to identify this parameter, a further assumption is needed. Matching, as with ordinary least squares, assumes the Conditional Independence Assumption (CIA), which is equivalent to assuming that the selection is only on observable characteristics.

$$(Y_1 - Y_0) \perp D / X \qquad \text{(CIA)}$$

The assumption of conditional independence between the outcome from and the selection into the programme imposes that the treated and non-treated population have on average the same outcome regarding the treatment effect[31]. Thus,

$$\begin{aligned} E(y_0 / X, D) &= E(y_0 / X) \\ E(y_1 / X, D) &= E(y_1 / X) \end{aligned} \qquad \text{(A2)}$$

In order to identify the average treatment on the treated, ordinary linear least squares further assumes homogeneity of the effect of the treatment; conditioning linearly on *X*, the effect of attending a prestigious institution is identical for all individuals. Rather than comparing individuals at different points of the *X* distribution, matching assumes that the CIA holds for individuals who have "similar" *X*. As a large number of covariates is usually required to imply CIA, Rosenbaum and Rubin (1983) show that it is equivalent to condition on the estimated probability of being treated (Pr (D=1/X)=P(X)) or on all the dimensions of *X*.

Various methods exist to implement matching estimates but they are all based on the same strategy of pairing individuals. They differ in the way the pairing is done or the weight given to a counterfactual individual. The generic formula is thus:

$$\hat{E}(Y_0 / \hat{P}(X_i)) = \sum_{j=1}^{J} w(\hat{P}(X_i), \hat{P}(X_j)) Y_{oj}$$

The expected outcome of no treatment for an individual *i* who attended a prestigious university is a weighted average of the earnings of individuals who did not go to such an institution, with the weight being attached to a given control (*j*) being a function of individuals *i* and *j* propensity scores. Basically, individuals who are the most similar to *i* in terms of observable characteristics (*X*) are given the highest weight.

In the simplest matching method, the weighting function has the following form: the individual (*j*) whose propensity score is the closest to $\hat{P}(X_i)$ is given a weight of 1, all other individuals, receive a weighting of 0; this is known as nearest neighbour matching[32]. In order to improve on the quality of the match and thus reduce bias, it is possible to introduce a calliper to the nearest neighbour match. A calliper (c_n) is

[31] Heckman et al. (1997) note that the CIA is in fact stronger than required to estimate the ATET; in this case, all that is required is: $E(Y_0 \mid X, D = 1) = E(Y_0 \mid X, D = 0)$. Alternatively, if the parameter of interest is the Average Treatment Effect on the Non-Treated, it suffices to have: $E(Y_1 \mid X, D = 1) = E(Y_1 \mid X, D = 0)$.

[32] This can be conducted with or without replacement. In this application, the number of control observations in the common support area is small, thus in order to reduce bias we decided to match with replacement.

simply an ad hoc limit where a match with a difference in propensity score greater than c_n is cancelled. The weighting function in the case of nearest neighbour with calliper is:

$$w(\hat{P}(X_i), \hat{P}(X_j)) = \begin{cases} 1 \text{ if } \quad \forall k \in D = 0, \quad j = \text{argmin}\{| \ \hat{P}(X_i) - \hat{P}(X_k) |\} \quad \& \, | \hat{P}(X_i) - \hat{P}(X_j) | \leq c_n \\ 0 \ \text{Otherwise} \end{cases}$$

If no match is found within the interval $[\hat{P}(X_i) - c_n, \hat{P}(X_i) + c_n]$ observation i is discarded. Discarded individuals indicate that the existence of common support is not a reasonable assumption. An alternative to using a single control individual is to rely on a kernel to provide weights to a group of control observations.

In this case, the weighting function becomes:

$$w(\hat{P}(X_i), \hat{P}(X_j)) = \frac{K\left[\dfrac{\hat{P}(X_i) - \hat{P}(X_j)}{b_n}\right]}{\sum_{k \in \{D=0\}} K\left[\dfrac{\hat{P}(X_i) - \hat{P}(X_k)}{b_n}\right]}$$

where K is the chosen kernel function and b_n is a bandwidth defining the extent of the interval from which control observations are sought[33].

In finite samples, different matching estimators produce different estimates because of systematic differences in which observations are assigned a positive weight and how the support problem is handled. The nearest neighbour estimator minimizes bias, as it chooses only the closest control observation. Kernel estimates on the other hand use more controls, which increases the average distance between the treated and the synthetic control individual, but reduces the variance of the estimates. The same trade-off between bias and variance exist in the choice of the bandwidth. A small bandwidth reduces bias (in the limit, it is similar to a nearest neighbour match), while a larger bandwidth reduces variance by using more information. According to Pagan and Ullah (1999, p118), "the key questions about kernel estimators therefore devolve to selection of kernel and window width (bandwidth)". However, the authors conclude that "in some ways it is still unclear whether automatic bandwidth selection is preferable to eye balling." So we report estimates for two bandwidths. One of the advantages of the chosen matching methods is that they make explicit the common support assumption.

[33] In this paper, we rely on the Epanechnikov kernel defined as follow:

$$K(j) = \begin{cases} \frac{3}{4}(1 - j^2) \ \text{ if } \ |j| < 1 \\ 0 \ \text{ Otherwise} \end{cases}$$