Empirical Essays in the Economics of Education

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Declaration

I, Stijn Broecke, hereby declare that this thesis and the work presented in it is entirely my own.

To Lara, for her patience and support.

Abstract

In the UK, recent advances in data linking and matching have enabled education economists to shed new light on old questions. This thesis builds on these data developments to investigate three separate questions in the economics of education. The chapters all have a geographical focus on the UK and all touch upon issues related to higher education in some capacity or other.

The first chapter deals with the determinants of subject choice and attainment. More specifically, it estimates the effects of an education policy (Triple Science) in England aimed at increasing the take-up and attainment of young people in science subjects. The results suggest some large and significant effects of the policy on later subject choice and attainment, and these appear to be particularly strong for boys and pupils from more deprived backgrounds.

The second chapter considers the question of whether it pays to attend more selective universities in the UK. I compare students who indicated preferences for, and were conditionally accepted to, the same universities - but who attended different ones because some failed to meet the conditions of their preferred offer. The results suggest that the university you attend matters to your earnings, with one standard deviation in selectivity leading to a 7% increase in earnings three and half years after graduation.

The third and final chapter explores the effect changes in university rankings have on applicant and institution behaviour in the UK. Universities that fall down the rankings experience small but statistically significant drops in the number of applications received, as well as in the average tariff score of applicants and accepted applicants. Although the effects found are stronger for certain types of students and institutions, they tend to be modest overall, and suggest that other factors play a more important role in attracting applicants to universities.

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1. Introduction

In the UK, recent advances in data linking and matching have enabled education economists to shed new light on old questions. Data on secondary school students has been matched to higher education records, allowing us to investigate the transition from school to university. Administrative records on applications and acceptances to university can be linked, through unique identifiers, to higher education data, permitting investigations of who is accepted to university, and who is not. These datasets can then be further linked to surveys of graduates, allowing us to study labour market outcomes, including employment, earnings and job satisfaction.

This thesis builds on these new developments in data linking and matching to investigate three separate questions in the economics of education. The chapters share a few more commonalities: all three have a geographical focus on the UK; and all touch upon issues related to higher education in some capacity or other.

The first chapter looks at the issue of subject choice and attainment. More specifically, it estimates the effects of an education policy (Triple Science) in England aimed at increasing the take-up and attainment of young people in science subjects. It uses secondary school census data matched to higher education records. The effect of the policy is identified by comparing two adjacent cohorts of pupils in schools that offer Triple Science to one cohort, but not to the other. The results suggest some large and significant effects of the policy on later subject choice and attainment, and these appear to be particularly strong for boys and pupils from more deprived backgrounds. This chapter is forthcoming in *Education Economics*.

The second chapter estimates the returns to university selectivity in the UK using administrative data on applications and admissions to university, linked to a survey of graduates three and a half years after graduation. It compares students who indicated preferences for, and were conditionally accepted to, the same universities - but who attended different ones because some failed to meet the conditions of their preferred offer. The results suggest that the university you attend matters to your earnings, with one standard deviation in selectivity leading to a 7% increase in earnings. This chapter has been submitted to the *Economics of Education Review*.

The third and final chapter explores the impact of university rankings on applicant and institution behaviour in the UK, using data on applications and acceptances to university linked to league table information and to surveys of fees charged to students. The results obtained offer fairly consistent evidence of a relationship between rank changes and applicant behaviour in the UK. Although the effects are stronger for certain types of students and institutions, they are modest overall and suggest that other factors may play a more important role in attracting applicants to institutions. This chapter is being re-submitted to the journal *Education Economics*.

2. Does Offering More Science at School Increase the Supply of Scientists? The Impact of Offering Triple Science at GCSE on Subsequent Educational Choices and Outcomes

2.1. Introduction

In the UK (as elsewhere in the world) the scientific and business communities frequently bemoan the shortage of science graduates and its potential negative impact on economic growth and international competitiveness: "Skills shortage is getting worse, bosses warn" (The Guardian, 2010); "Science teacher shortage will leave Britain lagging warn scientists" (The Mirror, 2010); "Lack of top researchers could harm UK plc" (BBC, 2011).

The alleged reasons for the shortage of scientists are many and complex, however at least some of the blame is put on the school curriculum which many commentators argue does not place enough emphasis on teaching scientific skills: in the UK, the Council for British Industry and the Royal Society regularly attack the Government's track record on education and argue that more needs to be done to increase the number of pupils studying science and mathematics (CBI, 2010b; Royal Society, 2010). In particular, it has been argued that the way science is usually taught at GCSE (the most common qualification taken by 15-16 year olds in England) is not sufficiently rigorous and demanding to prepare young people to study science at A Level (the most common qualification taken at ages 17-18) or, indeed, in higher education. The science lobby has strongly argued (CBI, 2008; CBI, 2010a; HMT, 2007) that more pupils should study Biology, Chemistry and Physics as three separate sciences at GCSE (called "Triple Science"[1]) because this is deemed to be the best preparation for the study of science later on. Yet statistics provided by the Department for Education for 2008 suggest that the majority of schools did not offer Triple Science and that merely 10% of pupils followed this option. These same statistics suggest that most students (53%) in England took Double Science - which is the combined study of Biology, Chemistry and Physics resulting in just two GCSEs[2].

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[1] From 2006 onwards, Triple Science was renamed "GCSE Separate Sciences" although the term Triple Science itself continues to be used.

[2] These figures are for all schools, including independent ones. Many independent school pupils will enter iGCSE science rather than a GCSE qualification. In addition, the figures are based on pupils achieving a grade in a science subject, and not all do. Together, these two categories account for around 7% of the

In response to this pressure, the Government announced in 2007 that it would allow every pupil who had reached a certain standard (Level 6) in their Key Stage 3 science examinations at age 14 to continue to study Triple Science at GCSE (DCSF, 2007). The stated intention of the policy was to increase the number of young people taking Physics and Chemistry at A Level and their attainment in those subjects. Ultimately, the policy aimed to increase the number of people taking science subjects in higher education, as well as the quality of the scientists entering the labour force. The announcement of the policy went hand-in-hand with the setting of a Government target to get 14% of all pupils in maintained schools in England studying Triple Science by 2014 - which was increased to 17% in 2009. This corresponds to approximately 100,000 pupils and, in 2007, around 53,000 pupils took Triple Science.

Many in the business and science communities are convinced of the effectiveness of Triple Science and have argued that it should be made compulsory for high achieving pupils (e.g. CBI, 2008; and CBI, 2010a). Yet, in the absence of experimental data with well-defined treatment and control groups, it is difficult to say anything conclusive about the effectiveness of Triple Science in raising the uptake of, and attainment in, science subjects. One particular problem is that the pupils who take Triple Science are different from those who do not: they tend to be high-attaining and they are likely to differ in terms of unobservable characteristics (e.g.: preferences, ambition, etc...) as well. As a result, it remains unclear to what extent the programme itself raises the uptake of, and attainment in, science subjects – or whether pupils who take Triple Science would have studied science subjects (and done well in them) even in the absence of the programme.

In this chapter, I try to retrieve the causal impact of Triple Science on later subject choice and attainment by exploiting the fact that some schools have dropped Triple Science from their curriculum, and others have taken it on. Adjacent cohorts of young people going through these schools will share similar characteristics (observable and unobservable) and will have been subjected to a similar school environment (observable and unobservable). By comparing the outcomes of two cohorts within the same school, one of which was offered Triple Science and one of which was not, I am able to address

cohort. The remaining 17% will take a variety of other science qualifications, mainly vocational ones like “Additional Applied”, BTEC/OCR, Double Applied (VGCSE) and GNVQ.

at least part of the selection bias associated with selection into the programme, thus providing a better estimate of its true impact.

This chapter presents the first attempt to estimate the causal effect of Triple Science on later subject choice and attainment. More generally, I am not aware of any economic studies which have looked at the effect of curriculum structure and offer on later educational subject choice and attainment. In this sense, I believe the current study is the first of its kind[3].

The results indicate that pupils who are offered Triple Science are 8.3% more likely to take A Level Chemistry; 13.4% more likely to take A Level Mathematics; and 15.0% more likely to achieve a grade A in A Level Physics. In addition, the effects of Triple Science are restricted to males only, and pupils from more deprived backgrounds appear to benefit most. More deprived pupils who were offered Triple Science were 13.7% more likely to choose Chemistry at A Level and 19.6% more likely to take Engineering and Technology in higher education.

The remainder of this chapter is set out as follows. Section 2.2 describes the data and provides some descriptive statistics. Section 2.3 discusses the methodology and section 2.4 provides the basic results. In section 2.5 the analysis is extended to certain sub-groups to test for heterogeneity in the treatment. Section 2.6 offers some discussion and concluding remarks.

2.2. Data and Descriptive Statistics

The data used in this chapter consists of matched administrative data: the National Pupil Database (NPD) for England matched to data from the Higher Education Statistics Agency (HESA).

The NPD is a longitudinal database of children in England holding detailed information on attainment (for pupils in both the maintained/state and independent/private sector) at all the Key Stages (KS2[4], KS3[5], KS4[6], and KS5[7]), as well as pupil characteristics

[3] Annex 2A contains a review of the literature on subject choice in schools and in higher education. There is also a wider literature which has looked at the effect of curriculum effects on earnings. See, for example: Altonji (2005) and Dolton and Vignoles (2002).

[4] Key Stage 2 refers to the four years of schooling in maintained schools in England, normally known as Year 3, Year 4, Year 5 and Year 6, when pupils are aged between 7 and 11. At the end of this stage, pupils are tested as part of the national programme of National Curriculum Tests, colloquially known as SATs. These tests cover English, Mathematics and Science.

(gender, ethnicity, mother tongue, Special Educational Needs (SEN), eligibility for Free School Meals (FSM), postcode deprivation indicators, and month of birth). Because pupil characteristics are generally not available for young people in the independent sector[8], the analysis is restricted to young people who were in the maintained sector at the time they sat their GCSEs.

These individual pupil records have been matched by the Department for Education to HESA data, which holds information on all people attending UK higher education institutions, including what subjects they study and which institutions they attend. HESA data matched to the NPD provides us with information on whether pupils entered higher education or not.

In addition, data from the Annual School Census (ASC) is merged on, which contains some information on staffing resources available to each school in England. Although the ASC does not contain information about the subject specialism of teachers, it does provide information on the number of qualified teachers, “other” teachers, technicians, as well as on the size of the school.

The dataset contains information on two cohorts: one consists of young people born in 1985 (who would have sat their GCSEs in 2001/02), the other of those born in 1986 (and who would have sat their GCSEs in 2002/03). The 1985 cohort could have been in higher education at the age of 18 in 2004/05 (19 in 2005/06), and the 1986 cohort could have been in higher education at the age of 18 in 2005/06 (19 in 2006/07).

As mentioned above, only young people who were in a maintained (state) Year 11 school are kept in the analysis in order to have socio-demographic information for most pupils in the dataset. In addition, only those pupils who were of the right academic age (i.e. those aged 15 at the end of KS4)[9] were retained. This leaves 547,924 individuals in

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[5] Key Stage 3 is the legal term for the three years of schooling in maintained schools in England, normally known as Year 7, Year 8 and Year 9, when pupils are aged between 11 and 14. At the end of this stage, pupils aged 14 - in Year 9 - are assessed as part of the national programme of National Curriculum assessment, including in English, Mathematics and Science.

[6] Key Stage 4 corresponds to the two final years of compulsory education when pupils are aged 15-16 and at the end of which they sit their GCSEs.

[7] The dataset holds detailed information on the Advanced Level General and Vocational Certificates of Education (GCE A Level and VCE A Level, respectively). These are the main qualifications sat by young people in England in Key Stage 5 (the two years of post-compulsory education for students aged 16-18. Unfortunately, the dataset does not hold any information on other, equivalent qualifications such as National Vocational Qualifications (NVQs), BTEC, or other vocational qualifications.

[8] Unless they have had a spell in the maintained sector. Around 7% of school children in England are educated in the independent sector.

[9] This gets rid of 144 observations in the 1985 cohort, and 227 observations in the 1986 cohort.

the 1985 cohort and 562,089 in the 1986 cohort – giving a total of 1,110,013 observations in the entire dataset.

Table 2-1 provides some basic socio-demographic descriptive statistics for the pupils in the dataset. Just under half the sample is female and almost 19% of pupils are from an ethnic minority background. Nearly 14% of pupils were on Free School Meals (FSM) at the age of 15, around 16% had special educational needs (SEN), and 9% had a mother tongue other than English. Table 2-1 also indicates some issues with the ethnicity and SEN variables. Both of these were affected by a change in classification systems between 2002 and 2003 and, although in theory it should be possible to match one system up to another, teething problems with the introduction of the new classification clearly led to some inconsistencies in these variables over time. To deal with this problem in the econometric models, a list of dummies will be included for all ethnicities and SEN, as well as interactions of these dummies with a cohort indicator.

Table 2-2 and Table 2-3 provide some information on the key measures of prior attainment used throughout this analysis: attainment on the KS2 and KS3 tests in English, Mathematics and Science. In practice, young people are awarded a "level" (taking discrete integer values from 1-6 at KS2 and from 1-9 at KS3), depending upon the difficulty of the paper they sat ("tier") and the score they achieved in it. I use the method employed by Chowdry et al. (2008) to transform these discrete levels into a continuous measure on a similar scale[10]. This allows the use of much more fine-grained measures of prior attainment, as well as comparisons of pupils who sat papers of different difficulties.

Table 2-2 provides an idea of what these variables look like. The KS2 attainment variables range from zero to a maximum of around seven, with a mean of just over four and a standard deviation ranging between 0.70 and 0.85. KS2 attainment information is missing for 9-10% of the sample. The KS3 attainment variables also have a minimum value of zero, but reach maxima of just under ten. Standard deviations range from 1.08 to 1.28 and attainment information is missing for 5-8% of the sample[11].

[10] I am grateful to the authors for providing me with their Stata syntax to derive these continuous KS2 and KS3 measures of prior attainment.

[11] I have also experimented with standardising these prior attainment variables, and this makes no substantial difference to the results presented in this chapter.

Table 2-1: Pupil Socio-Demographic Characteristics

	85 Cohort		86 Cohort		Total	
	#	%	#	%	#	%
Female	270,404	49.35	277,930	49.45	548,334	49.40
White, UK	452,403	82.57	450,438	80.14	902,841	81.34
White, Other	14,298	2.61	10,150	1.81	24,448	2.20
Asian, Indian	13,944	2.54	13,823	2.46	27,767	2.50
Asian, Pakistani	13,771	2.51	13,142	2.34	26,913	2.42
Asian, Bangladeshi	5,119	0.93	5,307	0.94	10,426	0.94
Asian, Other	115	0.02	2,970	0.53	3,085	0.28
Black, Caribbean	7,794	1.42	8,293	1.48	16,087	1.45
Black, African	6,962	1.27	7,673	1.37	14,635	1.32
Black, Other	4,352	0.79	2,367	0.42	6,719	0.61
Chinese	2,016	0.37	2,017	0.36	4,033	0.36
Mixed	266	0.05	9,879	1.76	10,145	0.91
Other, Unclassified, Missing	26,884	4.91	36,030	6.41	62,914	5.67
FSM	76,596	13.98	76,931	13.69	153,527	13.83
FSM Missing	1,177	0.21	0	0.00	1,177	0.11
SEN	95,896	17.50	82,214	14.63	178,110	16.05
Foreign Language	48,806	8.91	50,485	8.98	99,291	8.95
Language Missing	925	0.17	467	0.08	1,392	0.13

Notes: Table shows the number and proportion of each cohort with respective characteristic. E.g. 13.98% of the cohort born in 1985 were eligible for (and claimed) Free School Meals at the age of 15. FSM=Free School Meals. SEN=Special Educational Needs.

Table 2-2: Continuous Measures of KS2 and KS3 Attainment

	Mean	S.D.	Min.	Max.	% Missing
KS2 English Score	4.25	0.73	0.00	6.58	10
KS2 Mathematics Score	4.21	0.85	0.00	6.90	9
KS2 Science Score	4.33	0.70	0.00	6.89	9
KS3 English Score	5.40	1.15	0.00	9.73	8
KS3 Mathematics Score	5.71	1.28	0.00	9.95	5
KS3 Science Score	5.41	1.08	0.00	9.78	5

Notes: Table shows mean, standard deviation, minimum and maximum values, as well as % with missing information for the key measures of prior attainment used. Figures are for both 1985 and 1986 cohorts pooled. KS=Key Stage.

Panel B of Table 2-3 shows how attainment on these tests varies by: (i) whether or not the pupil took Triple Science at GCSE; and (ii) whether or not the pupil attended a school which offered Triple Science in that particular year. It is clear that: (i) pupils who took Triple Science had, on average, higher prior attainment than pupils who did not take Triple Science; and (ii) pupils attending schools where they were offered Triple Science had, on average, higher prior attainment than pupils whose schools did not offer Triple Science. As the p-values in this table show, these differences are all highly statistically significant.

Table 2-3 (Panel A) provides information on the number of pupils who took Triple Science, as well as on the number of pupils who attended schools where Triple Science was offered to them. Between 2002 and 2003, the proportion of pupils taking Triple Science increased from 4.3% to 4.6% of the cohort – i.e. the equivalent of 23,423 young people in 2002, and 25,822 in 2003. The number of people who attended schools where they were offered Triple Science increased by 1.5 percentage points, from 142,321 in 2002 (or 26.0% of the cohort) to 154,399 in 2003 (or 27.5% of the cohort).

Table 2-3: Number and Proportion of Pupils Taking and Being Offered Triple Science, and KS2 and KS3 Attainment by Triple Science Status

PANEL A		
	Took TS	Was Offered TS
N (1985 Cohort)	23,423	142,321
N (1986 Cohort)	25,822	154,399
N Total	49,245	296,720
% (1985 Cohort)	4.27	25.97
% (1986 Cohort)	4.59	27.47
% Total	4.44	26.73

PANEL B						
	Did Not Take TS	Took TS	Difference (p value)	Was Not Offered TS	Was Offered TS	Difference (p value)
KS2 English Score	4.22	4.85	0.64	4.20	4.37	0.18
			(0.00)			(0.00)
KS2 Mathematics Score	4.17	5.04	0.87	4.15	4.36	0.21
			(0.00)			(0.00)
KS2 Science Score	4.30	4.97	0.67	4.28	4.45	0.17
			(0.00)			(0.00)
KS3 English Score	5.35	6.42	1.07	5.31	5.63	0.32
			(0.00)			(0.00)
KS3 Mathematics Score	5.63	7.26	1.63	5.60	6.00	0.40
			(0.00)			(0.00)
KS3 Science Score	5.34	6.75	1.41	5.31	5.66	0.35
			(0.00)			(0.00)

Notes: Panel A shows the number and percentage of pupils who (i) took Triple Science; and (ii) were offered Triple Science in both the 1985 and 1986 cohorts, as well as the total for both cohorts together. Panel B shows the average Key Stage 2 and 3 attainment in English, Mathematics and Science for pupils who: (i) took Triple Science; and (ii) were offered Triple Science. Panel B also tests the statistical significance of the difference in prior attainment between these groups.

Table 2-4 summarises some key statistics for the schools in the dataset. There were 3,125 schools in 2002 and 3,103 in 2003. 24.2% of schools in 2002 offered Triple Science (n=755), compared to 25.8% of schools in 2003 (n=802) – an increase of 6.2%. As will be shown later, however, there is considerable movement in both directions as a large number of schools apparently stop offering Triple Science over this two-year period. Table 2-4 also provides information on the size of the schools and on some of the resources at their disposal (number of qualified teachers, number of other teachers, and technicians). As will be shown in the next section, schools that offer Triple Science have more qualified teachers but also tend to be larger, so that their pupil-teacher ratio is not very different from that of schools that did not offer Triple Science.

Table 2-4: School Characteristics

	No Triple Science (s.d.)	Triple Science (s.d.)
Average School Size	972	1,089
	(342.4)	(321.7)
Average Number of Qualified Teachers	57.7	64.7
	(20.1)	(19.5)
Average Number of Other Teachers	3.4	3.3
	(3.9)	(3.6)
Average Number of Technicians	5.2	5.7
	(2.2)	(2.3)

Notes: Table shows school characteristics at the end of KS4 for both the 1985 and 1986 cohorts (the relevant years being 2001/02 and 2002/03). Standard deviations (s.d.) in parentheses.

Finally, Table 2-5 summarises some of the key outcome variables looked at in this chapter, including: proportion attaining two A Level passes; subject choice at A Level (proportion entering examinations in Biology, Chemistry, Physics and Mathematics A Levels - conditional on entering any A Level examinations at all); attainment in those subjects at A Level (i.e. proportion attaining a grade A – conditional on having entered an examination in that subject[12]); the likelihood of being: in higher education[13]; in a Russell Group institution[14] (conditional on being in higher education); doing a STEM[15]

[12] A Level examinations are nationally set and assessed, so endogeneity is not an issue.
[13] Higher education in this chapter is defined as 1st Degree courses in Higher Education Institutions only. In other words, it excludes "other" undergraduate programmes such as Foundation Degrees, as well as 1st Degree courses at Further Education Colleges offering higher education courses. 1st Degree courses are the main type of course taken at undergraduate level and are considered the "traditional" form of higher education.
[14] The Russell Group is an association of 20 major research-intensive universities of the United Kingdom. These include the universities of: Birmingham, Bristol, Cambridge, Cardiff, Edinburgh, Glasgow, Leeds, Liverpool, Manchester, Newcastle, Nottingham, Oxford, Sheffield, Southampton, as well as Imperial

degree (conditional on being in higher education); as well as the likelihood of studying certain STEM subjects in higher education (again conditional on being in higher education)[16]. The table breaks this down by whether: (i) pupils took Triple Science or not; and (ii) pupils attended a school that offered Triple Science or not.

It is apparent that students who took Triple Science at GCSE are much more likely to take science courses at both A Level and in higher education, and they are more likely to do well at them. They are also more likely to achieve A Levels in the first place, to be in higher education at the age of 19, and to be attending a Russell Group institution. Similarly, pupils who attended a school that offered Triple Science are more likely to have a positive outcome on all these variables than pupils who attended schools that did not offer Triple Science – except when it comes to studying Mathematics and Computer Science[17].

College London, King's College London, the London School of Economics and Political Science, Queen's University Belfast and University College London. For more information, see: http://www.russellgroup.ac.uk/.

[15] STEM stands for Science, Technology and Engineering, and covers the following subject groupings of the Joint Academic Coding System (JACS): Medicine and Dentistry, Subjects Allied to Medicine (which includes Nursing), Biological Sciences, Veterinary Sciences, Agriculture and Related Subjects, Physical Sciences, Mathematical and Computer Sciences, Engineering, Technologies, and Architecture, Building and Planning. For more information about the JACS, see http://www.hesa.ac.uk/index.php?option=com_content&task=view&id=158&Itemid=233.

[16] Note that many of the outcome variables are conditional on having attained another outcome first. For example, the likelihood of attaining a grade A in A Level Physics is conditional on having entered an examination in that subject. There may be some selection issues which could bias the results. The standard way to circumvent this issue would be to model the selection procedure separately and then adjust for selection in the outcome equation. However, this procedure relies on finding a credible exclusion restriction which should appear in the selection equation, but not in the outcome equation. Unfortunately, such variables were not available in the dataset.

[17] This is due to the fact that Computer Science is more likely to be taken by students from lower socio-economic backgrounds with lower prior attainment.

Table 2-5: Summary of Key Outcome Variables, by Triple Science Status

	Did Not Take TS		Took TS				Was Not Offered TS		Was Offered TS			
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)
	#	%	#	%	Difference (iv)-(ii)	(p value)	#	%	#	%	Difference (x)-(viii)	(p value)
Two A Level Passes (1)	325,248	30.7	39,061	79.3	48.7	(0.00)	240,899	29.6	123,410	41.6	12.0	(0.00)
Took A Level Biology (2)	46,102	13.5	12,508	31.7	18.2	(0.00)	37,234	14.7	21,376	16.8	2.1	(0.00)
Took A Level Chemistry (2)	30,635	9.0	11,352	28.7	19.8	(0.00)	25,831	10.2	16,156	12.7	2.5	(0.00)
Took A Level Mathematics (2)	45,592	13.3	14,154	35.8	22.5	(0.00)	36,291	14.3	23,455	18.4	4.1	(0.00)
Took A Level Physics (2)	22,835	6.7	9,460	23.9	17.3	(0.00)	18,971	7.5	13,324	10.4	3.0	(0.00)
Grade A in A Level Biology (3)	7,757	16.8	3,965	31.7	14.9	(0.00)	6,498	17.4	5,224	24.4	7.0	(0.00)
Grade A in A Level Chemistry (3)	6,750	22.0	4,022	35.4	13.4	(0.00)	5,745	22.2	5,027	31.1	8.9	(0.00)
Grade A in A Level Physics (3)	4,681	20.5	3,313	35.0	14.5	(0.00)	4,040	21.3	3,954	29.7	8.4	(0.00)
Grade A in A Level Mathematics (3)	13,937	30.5	6,462	45.6	15.1	(0.00)	11,341	31.2	9,058	38.6	7.4	(0.00)
In HE at 19 (4)	275,162	25.9	34,512	70.1	44.1	(0.00)	204,718	25.2	104,956	35.4	10.2	(0.00)
In a Russell Group Institution at 19 (5) (6)	50,600	18.4	13,854	40.1	21.8	(0.00)	37,825	18.5	26,629	25.4	6.9	(0.00)
STEM in HE at 19 (5) (7)	101,507	36.9	18,467	53.5	16.6	(0.00)	78,728	38.5	41,246	39.3	0.8	(0.00)
Biological Sciences in HE at 19 (5)	25,936	9.4	3,873	11.2	1.8	(0.00)	19,724	9.6	10,085	9.6	0.0	(0.00)
Medicine, Dentistry and Veterinary Sciences in HE at 19 (5)	6,385	2.3	2,406	7.0	4.7	(0.00)	5,237	2.6	3,554	3.4	0.8	(0.00)
Physical Sciences in HE at 19 (5)	10,631	3.9	2,970	8.6	4.7	(0.00)	8,552	4.2	5,049	4.8	0.6	(0.00)
Engineering and Technology in HE at 19 (5)	10,270	3.7	2,465	7.1	3.4	(0.00)	8,109	4.0	4,626	4.4	0.4	(0.00)
Mathematics and Computer Science in HE at 19 (5)	16,383	6.0	2,474	7.2	1.2	(0.00)	12,768	6.2	6,089	5.8	-0.4	(0.00)

Notes: Table shows number and proportion achieving each outcome, by Triple Science (TS) status. For example: 31% of those who did not take TS achieved two A Level passes. (1) An "A Level Pass" is defined as obtaining a grade A-E. (2) Conditional on having been entered for A Level examinations (or equivalent). (3) Conditional on having been entered for examination in the subject. (4) "HE" includes 1st Degrees at higher education institutions only. (5) Conditional on being in higher education at 19. (6) For list of Russell Group institutions see: www.russellgroup.ac.uk (7) STEM stands for Science, Technology, Engineering and Mathematics. Subject groupings at higher education follow the JACS coding system.

2.3. Methodology

As was clear from Table 2-3, young people who attend schools that offer Triple Science are different from young people who do not. In particular, they tend to have much higher prior attainment. Table 2-6 further demonstrates that young people who attend schools that offer Triple Science are slightly more likely to be male, less likely to be on Free School Meals, more likely to be White UK, and less likely to have either Special Educational Needs or English as a second language. Furthermore, as shown by Table 2-7, the outcomes of interest are correlated with the above student characteristics. Young people who choose science subjects and do well at them are more likely to be male, from an ethnic minority background, not on FSM, with no SEN and with English as a foreign language. Finally, as indicated by Table 2-8, schools that offer Triple Science, although having more teachers, tend to be larger than schools that do not offer Triple Science.

Table 2-6: Characteristics of Pupils in Schools Offering Triple Science

	Was Not Offered TS	Was Offered TS		
	%	%	Difference	(p value)
Female	49.6	48.8	-0.8	0.00
FSM	14.3	3.9	-10.4	0.00
White, UK	81.3	82.4	1.1	0.00
White, Other	2.2	2.7	0.5	0.00
Asian, Indian	2.5	3.5	1.1	0.00
Asian, Pakistani	2.5	1.7	-0.8	0.00
Asian, Bangladeshi	1.0	0.3	-0.7	0.00
Asian, Other	0.3	0.5	0.2	0.00
Black, Caribbean	1.5	0.5	-1.0	0.00
Black, African	1.3	0.8	-0.6	0.00
Black, Other	0.6	0.3	-0.3	0.00
Chinese	0.3	0.9	0.5	0.00
Mixed	0.9	1.0	0.1	0.02
Other, Unclassified, Missing	5.7	5.5	-0.2	0.09
SEN	16.6	3.2	-13.5	0.00
Foreign Language	9.0	7.3	-1.8	0.00

Notes: Table shows the proportion of those who were and those who were not offered Triple Science with each characteristic. So, for example, 49.6% of those who were offered TS were female, compared to 48.8% of those who were not. The third column shows the difference between these proportions, and the fourth column shows the statistical significance of the difference.

Table 2-7: Selection of Outcomes by Student Characteristics

	Took A Level Biology	Took A Level Chemistry	Took A Level Physics	Took A Level Mathematics	HE at 19	Russell Group at 19	STEM at 19	ALL
Female	61.1	50.9	19.6	38.1	55.6	54.6	48.1	49.4
FSM	4.6	5.1	3.1	3.7	6.3	2.9	6.0	13.83
White, UK	75.9	71.0	80.8	76.1	76.4	80.0	76.3	81.34
SEN	2.4	2.9	3.7	2.6	4.3	2.4	4.5	16.05
Foreign Language	13.8	18.0	9.8	13.8	13.1	9.6	13.9	8.95

Notes: Table shows proportion of those who achieve each outcome who are female, on FSM, etc... Last column shows proportions for entire sample (two cohorts combined).

Table 2-8: Characteristics of Schools Offering Triple Science

	2002		2003	
	Schools Offering TS	Schools Not Offering TS	Schools Offering TS	Schools Not Offering TS
Average Year Size	188	171	192	177
	(63.67)	(61.57)	(62.26)	(61.95)
Average School Size	1,097	968	1,103	990
	(319.93)	(339.65)	(319.19)	(342.03)
Average Number of Qualified Teachers	65.1	57.7	65.3	58.6
	(19.27)	(20.11)	(19.68)	(20.32)
Average Number of Other Teachers	3.4	3.3	3.8	4.1
	(3.60)	(3.75)	(4.69)	(2.60)
Average Number of Technicians	5.7	5.3	6.0	5.4
	(2.38)	(2.37)	(2.60)	(2.39)

Notes: Table shows school characteristics (size and number of staff) for those that offered and those that did not offer Triple Science (TS) in 2001/02 and in 2002/03. These years correspond to the year in which the cohorts sat their KS4 examinations.

Many confounding factors are therefore at play, which render it difficult to discern the effect that Triple Science itself is having on subject choice and attainment. The richness of the data will allow us to deal with a large portion of these selection issues, by permitting us to include in our models detailed information on observables like prior attainment and socio-demographic characteristics. A potential problem remains, however, because selection into Triple Science may also be based on unobservable characteristics which, if themselves related with the outcomes of interest, would bias the estimate of the effect of Triple Science on later subject choice and attainment.

As way of mitigating this selection problem, school fixed effects are included into the model. This will eliminate any time-invariant unobserved heterogeneity at the school level and will allow us to identify the effect of Triple Science by exploring variation within schools over time. The attraction of this identification strategy is that we are comparing two adjacent cohorts of young people who went through the same school, but only one of which was offered Triple Science. Apart from the science curriculum offered to them, these two cohorts should be very similar to each other (both in terms of observable and unobservable characteristics) and would have been subjected to a very similar school environment. This approach essentially amounts to a difference-in-differences strategy, where changes in outcomes in treatment schools are compared to changes in outcomes in non-treatment schools. The difference in these changes is attributed to the Triple Science programme.

For the above methodology to work, however, there need to be a sufficient number of schools that change their science curriculum over the period observed in the dataset. This is indeed the case: there are 192 schools that did not offer Triple Science in 2002, but did offer it in 2003, and there are a further 145 schools that offered Triple Science in 2002, but stopped offering it in 2003[18]. This compares to 610 schools which offered it in both years, and 2,149 schools which offered it in neither years.

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[18] I use the same methodology as used by the Department for Education to identify schools that offer Triple Science: i.e. as long as at least one pupil in the school enters exams in all three separate science subjects, then the school is considered to be offering Triple Science. Using this methodology, there is a slight problem in identifying schools that do not offer Triple Science, however. This is because a school might be offering Triple Science, but no pupil decides to take it. In this case, a school would be wrongly classified as not offering Triple Science. In Annex 2C I describe two robustness checks I carried out to test the extent to which the conclusions drawn in this chapter are sensitive to how Triple Science schools are identified. First, I check whether in schools that start/stop offering Triple Science there is a simultaneous drop/increase in the number of pupils taking Double Science (the next best alternative to Triple Science). I find that this is indeed the case. Second, I increase the threshold for identifying schools that offer Triple Science from one pupil to two/three/four/five/six pupils, and re-run the analysis. The

The impact of Triple Science is therefore estimated using the following Linear Probability Model[19]:

$$Y_i = \beta_0 + \beta_1 TS_i + PD_i\gamma + PA_i\delta + CD_{gst}\theta + CA_{gst}\rho + SR_{st}\omega + \upsilon_t + \sigma_s \qquad (2i)$$

Where Y is the outcome of interest for pupil i and TS is a dummy variable indicating whether the pupil attended a school which offered Triple Science (so β_1 is the coefficient of interest). PD is a vector of pupil socio-demographic characteristics (including dummies for gender, ethnicity, Free School Meal status, Special Educational Needs, English as a foreign language, relative deprivation of the area the pupil lives in, and month of birth[20]) and PA is a vector measuring individual pupil attainment (six controls covering continuous KS2 and KS3 scores in each of English, Mathematics and Science)[21]. Both CD and CA capture the make-up of the year group g that the pupil is in when taking his/her GCSEs: the socio-demographic composition of the year group (e.g. proportion female, proportion on FSM, etc...) and the average KS2 and KS3 attainment of pupils in the year group. SR is a vector of school resources in year t, and controls for the size of the school (number of full-time equivalent pupils), the number of qualified (and other) teachers, and the number of technicians. υ_t is a dummy for the 1986 cohort and captures any time-specific effects, whereas σ_s represents a full set of school fixed effects. Equation (2i) is estimated by Ordinary Least Squares, adjusting for heteroscedasticity (as the outcomes are dichotomous) and allowing for clustering of the standard errors at the school level. Annex 2B provides more detail on each of the dependent and explanatory variables included in the analysis.

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results of this analysis are slightly different from the main results presented in this chapter – and one would expect them to be, as they are identified using a different set of schools. However, the overall conclusion that offering Triple Science has positive effects on later outcomes still holds.

[19] The Linear Probability Model was chosen for computational convenience – particularly in the case of models with a large number of fixed effects. However, one potential drawback of the LPM is that it assumes constant marginal effects. To test the robustness of the results, I have run logit models for each dependent variable using the full specification (but without school fixed effects). For each type of school (00, 10, 01 and 11) I calculated average school characteristics, and I derived the marginal effects at those average characteristics. I found that the marginal effects of Triple Science did not vary hugely across school types, and so the LPM results were kept in the main body of the chapter.

[20] Month of birth has been linked to various educational outcomes, including participation in higher education: HEFCE (2005), Crawford, Dearden and Meghir (2007) and Crawford and Dearden (2008).

[21] These controls may be highly collinear, and so models where just KS3 results were included have also been run. The results of these models are almost identical to the ones which include the full set of prior attainment controls, and so the latter are reported in this chapter.

Although this model should mitigate some of the bias resulting from selection into Triple Science based on unobservable characteristics, a few selection issues remain. One of these is that, once Triple Science is offered in a particular school, the selection of pupils into the programme is non-random. As a way round this, an “intention to treat” is estimated rather than the effect of “treatment on the treated” – i.e. the interest is in whether or not a cohort that was offered Triple Science is more likely to choose and do well in science subjects later on, and not in whether pupils who actually take Triple Science are more likely to do so.

A more difficult issue to address is whether pupils select into/out of schools depending on whether Triple Science will be offered or taken off the curriculum in any particular year. There are a number of reasons to believe that this type of selection is not a major problem. First, there is very little movement of pupils in and out of schools between KS3 (which is when pupils start secondary school) and KS4 (which is when they take their GCSEs) – fewer than 5% of pupils do so, and the proportion is very similar for schools that change their science curriculum and those that do not; in fact, the proportion is slightly lower for schools that drop/take on Triple Science (around 4% for both types of school). Re-running the analysis on the subset of pupils who remain in the same school between KS3 and KS4 does not alter the conclusions reached in this chapter[22]. Most importantly, although pupils might move in and out of schools in search of a better school (or one with a better reputation), it is very unlikely that pupils select into and out of schools on the basis of whether or not they offer Triple Science - particularly at the time when the pupils in this dataset were observed, when information about whether or not the school offered Triple Science was not included in the School Profile (which provides information to parents about the school). In addition, the time period under observation predates the big drive by Government and stakeholders to get Triple Science on the curriculum, so much of the current publicity around Triple Science and its supposed benefits did not exist.

The most fundamental challenge to the identification strategy proposed is whether the decision to start or stop offering Triple science at the school level is random or not and, in particular, whether the unobserved factors which lead to a change in the science curriculum on offer might, in turn, be correlated with the outcomes of interest. Any such time-variant unobserved heterogeneity at the school level correlated with the outcome

[22] Results are shown in Annex 2D.

variables would bias the estimates of the impact of offering Triple Science on later subject choice and attainment. By definition, it is not possible to assess how important this type of endogeneity is likely to be. Nevertheless, we can try and demonstrate that any changes in the Triple Science offer are unrelated to changes in observable characteristics at the school level. A lack of relationship between such observable changes and a switch in the Triple Science offer would provide some evidence that there are no major changes occurring at the school level which would be driving the results.

Table 2-9 explores some observable changes at the school level which might have been correlated with changes in the science curriculum on offer. One possible reason for dropping Triple Science might be staff turnover. However, the data suggest that the number of qualified teachers in schools that dropped Triple Science increased (from 63.3 to 64.0 full-time equivalents) rather than decreased between the two years covered by the dataset. Unfortunately, there is no way of verifying the subject specialism of those teachers, so it still possible that science teachers left the school and were substituted by non-science teachers (or, indeed, that a good science teacher was replaced by a bad one).

Another possibility is that those schools that dropped Triple Science from their curriculum did so because they had been experiencing drops in the average ability of their students over time. However, as Table 2-9 shows, even though schools that dropped Triple Science saw a drop in attainment in KS2 Mathematics and Science, the same was true for schools that took on Triple Science in that year. And, even though schools that dropped Triple Science from their curriculum also saw a slight fall in KS3 English attainment between cohorts, it is hard to see why that would affect the science curriculum on offer (particularly since KS3 Science and Mathematics scores were higher for the second cohort than for the first).

Table 2-9 also shows that there was no drop in the average number of pupils who had achieved Level 6 on their KS3 Science tests in those schools that dropped Triple Science from their curriculum: the number went from 50 in the cohort that was offered Triple Science to 59 in the cohort that was not. This increase is comparable to the one that happened in schools which went from not offering Triple Science to offering it: 51 to 63 pupils.

Table 2-9: Observable Changes at the School Level

		SCHOOL TREATMENT CATEGORY			
	Cohort	00	01	10	11
Year Group Size	1985	172	176	183	189
	1986	177	183	187	195
# of FTE Qualified Teachers	1985	57.7	60.9	63.3	65.7
	1986	58.3	61.3	64.0	66.5
Average KS2 English Score	1985	4.15	4.23	4.23	4.43
	1986	4.19	4.28	4.25	4.45
Average KS2 Mathematics Score	1985	4.15	4.22	4.24	4.47
	1986	4.09	4.19	4.16	4.44
Average KS2 Science Score	1985	4.27	4.34	4.33	4.52
	1986	4.24	4.33	4.30	4.50
Average KS3 English Score	1985	5.24	5.38	5.37	5.69
	1986	5.27	5.44	5.35	5.78
Average KS3 Mathematics Score	1985	5.52	5.65	5.64	6.14
	1986	5.56	5.74	5.67	6.18
Average KS3 Science Score	1985	5.18	5.27	5.27	5.71
	1986	5.36	5.50	5.42	5.86
# of Pupils Who Achieved Level 6 in KS3 Science	1985	46	51	50	79
	1986	54	63	59	90
# of Schools in Category		2149	192	145	610

Notes: This table shows key school and cohort level characteristics, by cohort as well as by school treatment category. "00" indicates schools that never offered Triple Science; "01" indicates schools that did not offer it in the first year, but did in the second; "10" indicates schools that initially offered Triple Science, and then dropped it from the curriculum; and "11" schools are those that offered Triple Science to both cohorts. The bottom line of the table shows the number of schools in each treatment category.

Finally, Table 2-9 shows how changes in absolute cohort size are not driving the decision to drop or offer Triple Science either. In all school types, including those that stopped and those that started offering Triple Science, the cohort size increased from one year to the next.

The Department for Education also kindly provided me with information on whether the schools in the dataset offered Triple Science in the two years following the ones observed. Analysis of this information suggests that, for the majority of switching schools identified in the dataset, the switch appears to be a permanent one. Of the schools that start offering Triple Science in the dataset, 52% continue to offer it in the next two years. Similarly, of the schools that stop offering Triple Science in the dataset, 79% do not offer it in the next two years. This suggests that, for most schools, the switch does not depend on the particular characteristics of the current cohort of students.

Although the analysis above suggests that the endogeneity of the decision to start/stop offering Triple Science may not necessarily be a problem, Table 2-9 does highlight one limitation: mover schools are different from non-mover schools and these differences are nearly always statistically significant. This matters because, in a model with school fixed effects, the identification of the Triple Science effect will come from mover schools only, and so this raises an issue about the external validity of the results obtained in this chapter. In defence, it is worth pointing out that mover schools are more "average" than non-mover schools, both in terms of size and average test scores. So the results found in this chapter are not based on some outliers and could still apply to the average school in England. Second, there are a relatively large number of mover schools (337 or 11% - i.e. just over one in ten schools switch between the two years observed in the dataset): so the results obtained apply to a large subset of schools. Finally (and as documented in section 2.4 below), the positive effects of offering Triple Science are also found in models without school fixed effects – suggesting that the results do not apply to mover schools only.

2.4. Results

The basic results of the analysis are in Table 2-10, which presents the effect of attending a school that offers Triple Science on the outcomes of interest using variants of the LPM model specified in equation (2i). Only the coefficients on the "Triple Science" variable are shown (i.e. whether or not the student attended a school that offered Triple Science). Table 2-11 then translates these coefficients into percentage changes from the baseline probability for young people who were not offered Triple Science. Only a selection of specifications from Table 2-10 has been included in Table 2-11.

Column (i) in these tables presents the "raw" effect of attending a school that offers Triple Science and corresponds to the descriptive statistics presented in Table 2-5. These raw effects of attending a Triple Science school are very large if compared to the baseline for young people who did not attend such schools. For example, it increases the likelihood that someone will: attain two A Level passes by 40.5%; take A Level Physics by 20.8%; attain a grade A in A Level Physics by 39.4%; be in higher education at 19 by 40.5%; and study Physical Sciences in higher education by 15.2%.

Table 2-10: Effect of Being Offered Triple Science – Main Results

		(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)
Two A Level Passes	Triple Science	0.120	0.0801	0.0235	0.0168	0.00694	0.00419	0.00180
	(s.e.)	(0.00678)***	(0.00511)***	(0.00241)***	(0.00233)***	(0.00214)***	(0.00212)**	(0.00260)
Took A Level Biology (1)	Triple Science	0.0209	0.0202	-0.00176	-0.00290	-0.00414	-0.00449	0.00536
	(s.e.)	(0.00327)***	(0.00317)***	(0.00257)	(0.00260)	(0.00263)	(0.00264)*	(0.00393)
Took A Level Chemistry (1)	Triple Science	0.0249	0.0244	0.00153	0.00118	-0.000309	-0.000156	0.00849
	(s.e.)	(0.00307)***	(0.00289)***	(0.00206)	(0.00205)	(0.00207)	(0.00209)	(0.00331)**
Took A Level Physics (1)	Triple Science	0.0297	0.0222	0.00522	0.00548	0.00540	0.00538	0.00452
	(s.e.)	(0.00272)***	(0.00222)***	(0.00167)***	(0.00165)***	(0.00163)***	(0.00165)***	(0.00267)*
Took A Level Mathematics (1)	Triple Science	0.0409	0.0333	-0.00116	0.000602	0.00367	0.00367	0.0100
	(s.e.)	(0.00400)***	(0.00341)***	(0.00234)	(0.00229)	(0.00225)	(0.00225)	(0.00348)***
Grade A in A Level Biology (2)	Triple Science	0.0698	0.0660	0.0112	0.0103	0.00999	0.0112	0.00654
	(s.e.)	(0.00762)***	(0.00720)***	(0.00501)**	(0.00488)**	(0.00475)**	(0.00482)**	(0.0101)
Grade A in A Level Chemistry (2)	Triple Science	0.0888	0.0799	0.0236	0.0224	0.0191	0.0202	0.0130
	(s.e.)	(0.00925)***	(0.00876)***	(0.00647)***	(0.00624)***	(0.00611)***	(0.00616)***	(0.0127)
Grade A in A Level Physics (2)	Triple Science	0.0839	0.0770	0.0133	0.0119	0.0105	0.0115	0.0319
	(s.e.)	(0.00908)***	(0.00881)***	(0.00591)**	(0.00597)**	(0.00585)*	(0.00584)**	(0.0143)**
Grade A in A Level Mathematics (2)	Triple Science	0.0737	0.0670	0.00536	0.00157	-0.000138	0.000406	-0.00177
	(s.e.)	(0.00858)***	(0.00813)***	(0.00554)	(0.00555)	(0.00569)	(0.00571)	(0.0115)
In HE at 19	Triple Science	0.102	0.0722	0.0245	0.0174	0.00439	0.00306	0.00373
	(s.e.)	(0.00620)***	(0.00476)***	(0.00239)***	(0.00223)***	(0.00188)**	(0.00188)	(0.00229)
In a Russell Group Institution at 19 (3)	Triple Science	0.0689	0.0567	0.0183	0.0111	0.00123	0.00140	0.00413
	(s.e.)	(0.00595)***	(0.00554)***	(0.00359)***	(0.00333)***	(0.00320)	(0.00318)	(0.00448)
STEM in HE at 19 (3)	Triple Science	0.00842	0.00258	-0.00887	-0.00386	-0.0000477	0.000764	0.00720
	(s.e.)	(0.00291)***	(0.00281)	(0.00279)***	(0.00274)	(0.00272)	(0.00273)	(0.00548)

		(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)
Biological Sciences in HE at 19 (3)	Triple Science	-0.000259	-0.00127	-0.00316	-0.00200	-0.0000879	0.0000464	-0.00173
	(s.e.)	(0.00141)	(0.00138)	(0.00140)**	(0.00143)	(0.00146)	(0.00146)	(0.00343)
Medicine, Dentistry and Veterinary Sciences in HE at 19 (3)	Triple Science	0.00828	0.00802	0.00247	0.00121	-0.000788	-0.000522	-0.000421
	(s.e.)	(0.00121)***	(0.00117)***	(0.000933)***	(0.000897)	(0.000900)	(0.000902)	(0.00158)
Physical Sciences in HE at 19 (3)	Triple Science	0.00633	0.00271	-0.00167	-0.000704	0.000318	0.000395	0.00160
	(s.e.)	(0.00110)***	(0.000997)***	(0.000987)*	(0.000982)	(0.000979)	(0.000988)	(0.00232)
Engineering and Technology in HE at 19 (3)	Triple Science	0.00447	0.000914	-0.000995	-0.000187	0.000385	0.000594	0.00298
	(s.e.)	(0.00119)***	(0.000941)	(0.000925)	(0.000910)	(0.000914)	(0.000914)	(0.00210)
Mathematics and Computer Science in HE at 19 (3)	Triple Science	-0.00435	-0.00455	-0.00500	-0.00149	0.000680	0.000723	-0.000457
	(s.e.)	(0.00135)***	(0.00120)***	(0.00121)***	(0.00112)	(0.00113)	(0.00113)	(0.00291)

Notes: Each cell reports the coefficient on the variable “Triple Science” (a dummy indicating whether the individual was offered Triple Science or not) from a different regression based on model (2i) discussed in the main body of the chapter. Each row is for a different outcome variable, and more explanatory variables are introduced as we move from left to right in the table. Specifically: Model (i) includes an indicator for being offered Triple Science only. Model (ii) adds a cohort indicator and individual socio-demographic information. Model (iii) adds individual attainment variables. Year group socio-economic information and attainment are added in Models (iv) and (v), respectively. Model (vi) further includes information about school resources and, finally, Model (vii) adds school fixed effects.

* p<0.10 **<0.05 ***<0.01

(1) Conditional on having been entered for A Level or equivalent qualifications; (2) Conditional on having been entered for examination in the subject; (3) Conditional on being in HE at 19.

Table 2-11: Effects of Being Offered Triple Science – Percentage Increase on Baseline

	Increased Likelihood According to Specification:			
	(i)	(iii)	(xi)	(xii)
Two A Level Passes	40.5%	7.9%	1.4%	
Took A Level Biology	14.2%			
Took A Level Chemistry	24.5%			8.3%
Took A Level Physics	20.8%	3.7%	3.8%	
Took A Level Mathematics	54.7%			13.4%
Took A Level Biology	40.0%	6.4%	6.4%	
Grade A in A Level Chemistry	40.0%	10.6%	9.1%	
Grade A in A Level Physics	39.4%	6.3%	5.4%	15.0%
Grade A in A Level Mathematics	23.6%			
In HE at 19	40.5%	9.7%		
In a Russell Group Institution at 19	37.3%	9.9%		
STEM in HE at 19	2.2%	-2.3%		
Biological Sciences in HE at 19		-3.3%		
Medicine, Dentistry and Veterinary Sciences in HE at 19	32.4%	9.7%		
Physical Sciences in HE at 19	15.2%			
Engineering and Technology in HE at 19	11.3%			
Mathematics and Computer Science in HE at 19	-7.0%	-8.0%		

Notes: Table shows the percentage increase in the likelihood of achieving each outcome for young people who have been offered Triple Science. The baseline probabilities used for these calculations are the ones reported in Column (viii) of Table 2-5. Each numbered column in the table above corresponds to the effect estimated in the corresponding specification in Table 2-10. Only the effects for specifications (i), (iii), (vi) and (vii) are reported. For example, looking at the first row in specification (vi): individuals who were offered Triple Science were 1.4% more likely to achieve two A Level passes compared to individuals who were not offered Triple Science. Blanks signify that the coefficient of the "Triple Science" dummy was insignificant at the 5% level.

In subsequent columns, additional controls are added. Column (ii) adds an indicator for which cohort the individual belonged to (υ_t in equation (2i)) as well as controls for individual socio-demographic characteristics (PD_i); column (iii) adds individual prior attainment variables (PA_i); column (iv) adds socio-demographic characteristics of the individual's year group (CD_{gst}); column (v) adds the average attainment of the year group (CA_{gst}); column (vi) adds some information on school resources (SR_{st}); and, finally, column (vii) adds school fixed effects (σ_s).

As column (iii) shows, the addition of controls for individual prior attainment considerably reduces the effect of attending a school that offers Triple Science. Taking the same examples as above, the effect on the likelihood of attaining two A Level passes is reduced from a "raw" 40.5% to 7.9%; the effect on the likelihood of taking A Level Physics is reduced to 3.7%; the effect on the likelihood of achieving a grade A in A Level Physics is reduced to 6.3%; and the effect on the likelihood of being in higher education at 19 is reduced to 9.1%. The effect on the likelihood of studying Physical Science in higher education is now negative and no longer statistically significant at conventional levels.

The inclusion of cohort and school characteristics (specification (vi)) further reduces the effect of having attended a school that offered Triple Science. None of the effects on higher education outcomes are now any longer statistically significant, and there have been further reductions in the effects on A Level outcomes. Individuals who attended schools that offered Triple Science are: 1.4% more likely to achieve two A Level passes; 3.8% more likely to choose A Level Physics; 6.4% more likely to choose A Level Biology; 9.1% more likely to achieve a grade A in A Level Chemistry and 5.4% more likely to achieve a grade A in A Level Physics.

Specification (vii) adds in school fixed effects. Whereas in previous columns the effect of offering Triple Science was identified using variation across all schools, in specification (viii) we rely on variation within schools. This changes the results somewhat – suggesting that controlling for unobserved school characteristics is important. According to this (preferred) model, offering Triple Science to pupils increases their likelihood of: taking A Level Chemistry by 8.3%; taking A Level Mathematics by 13.4%; and achieving a grade A in A Level Physics by 15.0%[23].

2.5. Heterogeneous Effects

This section explores whether the effect of offering Triple Science varies depending on the characteristics of the pupils it is offered to. Differential effects are shown for: (a) pupils who were in schools that dropped Triple Science as opposed to those who were in schools that took on Triple Science; (b) pupils who had and did not have high prior attainment in science; (c) males v. females; (d) more versus less deprived pupils; and (e) young people who attended schools with sixth forms, and those who did not. The results of this analysis are summarised in Table 2-12.

[23] As a falsification exercise, I estimated the effect of offering Triple Science on English at A Level. The full analysis is presented in Annex 2E. In brief, I find no positive effect of offering Triple Science on the likelihood of taking up English at A Level – which is what one would expect.

Table 2-12: Heterogeneity in the Effects of Being Offered Triple Science

		(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)
		Treatment Type		**Level 6 in KS3 Science**		**Gender**		**Deprivation**		**Schools with Sixth Form**	
		Take on TS	**Drop TS**	**No**	**Yes**	**Male**	**Female**	**50% Most**	**50% Least**	**No**	**Yes**
Two A Level Passes	Triple Science	0.00256	0.000404	0.00259	-0.000436	0.000446	0.00341	0.00189	0,00248	0.00356	0.000731
	(s.e.)	(0.00368)	(0.00445)	(0.00275)	(0.00483)	(0.00330)	(0.00370)	(0.00314)	(0.00384)	(0.00420)	(0.00330)
Took A Level Biology (1)	Triple Science	0.0101	0.00292	0.00354	0.00850	0.0150	-0.00155	0.00396	0,00626	0.00401	0.00482
	(s.e.)	(0.00553)*	(0.00639)	(0.00379)	(0.00576)	(0.00651)**	(0.00493)	(0.00608)	(0.00483)	(0.00676)	(0.00476)
Took A Level Chemistry (1)	Triple Science	0.0102	0.00462	0.00363	0.00953	0.0128	0.00445	0.0130	0,00633	0.00976	0.00743
	(s.e.)	(0.00431)**	(0.00571)	(0.00308)	(0.00493)*	(0.00520)**	(0.00393)	(0.00526)**	(0.00409)	(0.00681)	(0.00379)**
Took A Level Physics (1)	Triple Science	-0.000435	0.00687	0.00449	0.00310	0.00698	0.000163	0.00624	0,00458	0.000225	0.00576
	(s.e.)	(0.00340)	(0.00500)	(0.00193)**	(0.00410)	(0.00549)	(0.00221)	(0.00368)*	(0.00337)	(0.00447)	(0.00329)*
Took A Level Mathematics (1)	Triple Science	0.00866	0.0117	0.000934	0.0131	0.0173	0.00202	0.00974	0,0107	0.0104	0.0103
	(s.e.)	(0.00508)*	(0.00521)**	(0.00313)	(0.00508)***	(0.00549)***	(0.00417)	(0.00501)*	(0.00451)**	(0.00672)	(0.00401)**
Grade A in A Level Biology (2)	Triple Science	-0.00573	0.0227	0.0234	0.0000977	0.0309	-0.0107	0.0131	0,000093	0.0391	-0.00167
	(s.e.)	(0.0153)	(0.0152)	(0.0205)	(0.0109)	(0.0163)*	(0.0140)	(0.0160)	(0.0128)	(0.0182)**	(0.0120)
Grade A in A Level Chemistry (2)	Triple Science	-0.00586	0.0328	0.0211	0.00439	0.0396	-0.0192	0.0375	-0,0103	0.0488	0.00134
	(s.e.)	(0.0173)	(0.0226)	(0.0348)	(0.0134)	(0.0199)**	(0.0182)	(0.0227)*	(0.0157)	(0.0252)*	(0.0149)
Grade A in A Level Physics (2)	Triple Science	0.0182	0.0645	0.129	0.0173	0.0264	0.0688	0.0466	0,0281	0.000245	0.0377
	(s.e.)	(0.0192)	(0.0232)***	(0.0502)**	(0.0146)	(0.0151)*	(0.0419)	(0.0283)*	(0.0176)	(0.0290)	(0.0163)**
Grade A in A Level Mathematics (2)	Triple Science	-0.00307	0.00141	-0.0327	-0.00423	-0.00720	0.00103	0.00869	-0,00881	-0.00136	-0.00267
	(s.e.)	(0.0160)	(0.0186)	(0.0354)	(0.0126)	(0.0158)	(0.0197)	(0.0197)	(0.0146)	(0.0206)	(0.0139)
In HE at 19	Triple Science	0.00390	0.00475	0.00305	0.00574	0.00456	0.00304	0.00481	0,00353	0.00405	0.00316
	(s.e.)	(0.00322)	(0.00414)	(0.00242)	(0.00480)	(0.00304)	(0.00326)	(0.00281)*	(0.00356)	(0.00332)	(0.00304)
In a Russell Group Institution at 19 (3)	Triple Science	-0.0000133	0.0113	-0.00281	0.00806	0.00508	0.00286	0.0118	0.000945	0.0156	-0.000753
	(s.e.)	(0.00606)	(0.00745)	(0.00489)	(0.00646)	(0.00649)	(0.00601)	(0.00634)*	(0.00573)	(0.00761)**	(0.00538)

		(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)
		Treatment Type		Level 6 in KS3 Science		Gender		Deprivation		Schools with Sixth Form	
		Take on TS	Drop TS	No	Yes	Male	Female	50% Most	50% Least	No	Yes
STEM in HE at 19 (3)	Triple Science	0.00799	0.00322	0.0106	0.00521	0.0171	-0.00125	0.0139	0.00515	-0.00488	0.0110
	(s.e.)	(0.00764)	(0.00908)	(0.00853)	(0.00701)	(0.00920)*	(0.00705)	(0.00966)	(0.00662)	(0.0112)	(0.00625)*
Biological Sciences in HE at 19 (3)	Triple Science	-0.000299	-0.00110	-0.00144	-0.00153	0.00777	-0.00894	0.00131	-0.00292	-0.00239	-0.00179
	(s.e.)	(0.00497)	(0.00576)	(0.00505)	(0.00448)	(0.00482)	(0.00497)*	(0.00520)	(0.00436)	(0.00602)	(0.00425)
Medicine, Dentistry and Veterinary Sciences in HE at 19 (3)	Triple Science	-0.00208	0.00281	0.0000207	-0.00128	0.00156	-0.00190	-0.00127	-0.0000883	0.00130	-0.00163
	(s.e.)	(0.00214)	(0.00287)	(0.00197)	(0.00234)	(0.00229)	(0.00241)	(0.00259)	(0.00208)	(0.00258)	(0.00195)
Physical Sciences in HE at 19 (3)	Triple Science	0.00277	0.00121	0.00333	-0.000659	0.000946	0.00178	0.00477	-0.000172	-0.0000220	0.00225
	(s.e.)	(0.00333)	(0.00375)	(0.00237)	(0.00336)	(0.00413)	(0.00261)	(0.00337)	(0.00296)	(0.00449)	(0.00270)
Engineering and Technology in HE at 19 (3)	Triple Science	0.00469	-0.00219	0.00584	0.000997	0.00572	0.000334	0.00727	0.000584	-0.00113	0.00452
	(s.e.)	(0.00287)	(0.00373)	(0.00315)*	(0.00283)	(0.00448)	(0.00122)	(0.00335)**	(0.00266)	(0.00406)	(0.00248)*
Mathematics and Computer Science in HE at 19 (3)	Triple Science	-0.00254	0.000833	0.000987	-0.000709	0.00000705	-0.000661	-0.00231	0.000678	-0.00553	0.00153
	(s.e.)	(0.00405)	(0.00473)	(0.00423)	(0.00349)	(0.00602)	(0.00212)	(0.00466)	(0.00343)	(0.00533)	(0.00341)

Notes: Table shows coefficients on the "Triple Science" variable for variants of specification (vii) in Table 2-10 where the sample has been restricted to: (i) young people in schools that never offer Triple Science and schools that take on Triple Science; (ii) young people in schools that always offer Triple Science and schools that drop it; (iii) young people who did not achieve Level 6 in their KS3 Science exams; and (iv) young people who did; (v) males; (vi) females; (vii) the 50% most deprived pupils; and (viii) the 50% least deprived; (ix) young people in schools that do not have their own sixth form; and (x) young people who are in schools that do.

* p<0.10 **<0.05 ***<0.01

(1) Conditional on having been entered for A Level or equivalent qualifications; (2) Conditional on having been entered for examination in the subject; (3) Conditional on being in HE at 19.

Columns (i) and (ii) compare the effect of dropping Triple Science as opposed to taking it on. So far, it has been assumed that the effect of Triple Science is symmetrical – i.e. that it is the same in schools that drop it as in schools that take it on. However, there are reasons to believe that this may not be so. It may be the case that setting up a Triple Science programme is a costly investment and that it takes a while before it is up and running properly. As a result, effects may only be discernible once the programme has been running for a number of years. By contrast, one might expect the effect of taking Triple Science off the curriculum to be more sudden and marked. Column (i) shows the coefficient on the Triple Science variable in a regression run on the subsample of schools that either never offered Triple Science, or those that started offering it in the second year of the dataset. So this column explores the effect of taking on Triple Science. Column (ii), on the other hand, does the same on the subsample of schools that always offered Triple Science and those that initially offered it, but then dropped it. So here we look at the effect of discontinuing a Triple Science programme. The results provide no evidence for the asymmetry hypothesis.

In columns (iii) and (iv), we check whether the Triple Science effect varies depending on the aptitude for science of the pupils who are offered it. As mentioned in the introduction to this chapter, the Department for Education's policy applies mainly to those young people who achieved Level 6 (or higher) on their KS3 Science test. So far, the analysis presented has covered all young people (regardless of their KS3 Science attainment). The analysis is therefore rerun separately for young people who achieved Level 6 or higher on their KS3 science test, and those who did not. Of the 1985 (1986) cohort, 30% (34%) achieved Level 6 or higher in their KS3 Science test and, of these, 34% (35%) attended schools that offered Triple Science. The results suggest that there are positive effects of offering Triple Science for pupils who did not achieve Level 6, as well as for pupils who did achieve Level 6. This indicates that it might be useful to encourage take-up of Triple Science even in lower attaining schools.

Columns (v) and (vi) explore whether there are any gender differences in the effect of offering Triple Science. The results are striking and suggest that the effect of Triple Science is restricted to males only. This is because, if on offer, males are considerably more likely to take up Triple Science than females: in 1985 (1986), 5.0% (5.3%) of males took Triple Science, compared to 3.5% (3.9%) of women. These findings suggest that policy-makers concerned about raising the proportion of females taking science in higher education should think about other ways of making science more attractive and interesting to women.

Columns (vii) and (viii) explore whether more deprived pupils stand to gain more from being offered Triple Science than less deprived pupils. Again, this is an important policy question, because there is now ample evidence to demonstrate that there is a labour market premium for holding a science degree[24]. To answer this question, the sample is split in two: the 50% most deprived pupils (as defined by the Income Deprivation Affecting Children Index (IDACI[25])) and the 50% least deprived pupils. The regressions are then rerun on the two samples separately. As in the case of gender, the results are remarkable: most of the effects of Triple Science are found for the 50% most deprived pupils. Deprived pupils who were offered Triple Science were 13.7% more likely to choose Chemistry at A Level and 19.6% more likely to take Engineering and Technology in higher education. In addition, pupils from more deprived backgrounds who were offered Triple Science were more likely to: take A Levels in Physics and Mathematics; achieve a grade A in A Level Mathematics and Chemistry; be in higher education at 19; and be in a Russell Group institution at 19 – although all of these latter effects are only significant at the 10% confidence level. These results are strongly supportive of the drive to make Triple Science available to all those pupils who could benefit, but are currently not offered it.

Finally, columns (ix) and (x) explore whether or not the effects found are restricted to schools that have their own sixth form. In those schools, the Triple Science effect might be caused simply by teachers and headmasters having an incentive to get pupils to progress to (science) A Levels and do well in them, in which case the Triple Science effect would in fact be a sixth form effect. In the dataset, out of 192 schools that took on Triple Science, 73 did not have their own sixth form. Similarly, out of 145 schools that dropped Triple Science, 55 did not have their own sixth form. The results in columns (ix) and (x) of Table 2-12 suggest that the effect of Triple Science can be detected in both types of schools.

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[24] See, for example, O'Leary and Sloane (2005), PWC (2005) and Chevalier (2009).

[25] IDACI measures the proportion of children under the age of 16 in an area living in low income households. It is a supplementary index to the Indices of Multiple Deprivation and is given at super output area level. Further information is available from http://www.communities.gov.uk/.

2.6. Conclusion

This chapter offered an attempt at evaluating an English Government policy which aims to increase the number of pupils taking A Levels in Physics and Chemistry, their attainment in those subjects and, ultimately, the number of young people studying science in higher education. The policy consists in offering pupils a more intensive option of studying science when they are aged 15 (Triple Science), in the hope that this will better prepare them for the study of science at a higher level. I argued that one can make use of the fact that some schools changed the intensity of their science offer to study the causal effect of offering Triple Science on pupil subject choice and attainment by exploring within-school variation.

The results indicate that pupils who are offered Triple Science are 8.3% more likely to take A Level Chemistry; 13.4% more likely to take A Level Mathematics; and 15.0% more likely to achieve a grade A in A Level Physics. In addition, it was found that the effects of Triple Science are restricted to males only and that pupils from more deprived backgrounds appear to benefit most. In particular, more deprived pupils who were offered Triple Science were 13.7% more likely to choose Chemistry at A Level and 19.6% more likely to take Engineering and Technology in higher education.

These effects appear very large. However, these are increases on a very small baseline. For example, the proportion of pupils taking A Level Mathematics was only 5.4% (or around 30,000 pupils) a year. So, if Triple Science were made available to all pupils achieving Level 6 at KS3 Science (i.e. an additional 145,000 students in the first cohort in the dataset and an additional 174,000 in the second cohort – over and above the 18,000 (19,000) who already received it in the first (second) cohort), then this would lead to an estimated increase in the number of young people with an A Level in Mathematics of around 2,150 in the first cohort of the dataset, and around 2,500 in the second cohort of the dataset. These represent increases in the number of young people with A Level Mathematics of 7.2% and 8.4%, respectively.

Given these small numbers, it is perhaps not surprising that very few statistically significant effects of offering Triple Science on subject choice in higher education were found. In addition, there are a number of potential benefits of Triple Science this chapter was not able to explore. For example, even if offering Triple Science does not have a vast impact on subject choice in higher education, it may still produce scientists of a higher “quality” – which could be reflected, for instance, in the proportion of graduates who achieve a 1^{st} class degree, or the proportion of students taking more difficult optional modules. Only further data-linking to trace these students through to graduation (and possibly into the labour market) could bring an answer to these questions.

3. University Selectivity and Earnings: Evidence from UK Data on Applications and Admissions to University

3.1. Introduction

All around the world, students compete to gain admission to the best universities. Although the reasons are likely to be complex and multifaceted, the expectation of higher earnings in the labour market is at least one important motivating factor. Despite a substantial and growing body of research, however, it is still unclear to what extent a causal relationship exists between attending a more selective institution and earning a wage premium in the labour market. The complicating factor is that selection into universities is non-random and students with higher earning potential tend to attend better institutions.

Non-random selection into universities can be based on observable characteristics (e.g. prior attainment, gender, ethnicity, etc...) and a large number of papers[26] have credibly controlled for such selection, sometimes using matching methods. Almost without exception, this research has found a positive relationship between university selectivity/“quality”[27] and earnings.

In addition, non-random selection may be based on unobservable characteristics, like motivation, networks, etc... which may themselves be correlated with higher earnings. Failure to adequately control for such selection would bias upwards estimates of the impact of university selectivity on wages.

A number of techniques have been employed in the literature to deal with the problem of selection on unobservable characteristics, including: twin studies (Behrman et al, 1996a), sibling fixed effects (Lindahl and Regner, 2005), instrumental variables

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[26] Some recent examples include: Datcher, Loury and Garman (1995), Monk (2000), Black and Smith (2004), Black and Smith (2006) for the US; Naylor et al (2000), Chevalier and Conlon (2003), Hussain et al (2009) and Chevalier (2010) for the UK.

[27] This chapter looks at institutional selectivity rather than “quality” because the latter is considered to be a complex and multidimensional concept, and hence difficult to measure. The measures of institutional “quality” traditionally used in the literature (and advocated by Black and Smith, 2006) are identical (or similar to) the kind of indices used in university league table publications – and there is a vast literature criticising these as indicators of university quality (Provan and Abercromby, 2000; Clarke, 2002; Eccles, 2002; Yorke and Longden, 2005; Turner, 2005; Dill, 2006; Birnbaum, 2007). Using the term university “quality” also implicitly suggests that the higher earnings associated with attending better “quality” institutions must be attributable to something the institution itself does (e.g. better teaching, or better support facilities, etc...) – whereas the true cause of higher earnings may purely be a signalling or network effect. A measure of selectivity leaves these possibilities wide open.

(Behrman et al, 1996b), selection models (Brewer et al, 1999), within-group estimates of students who applied and were accepted to similar colleges (Dale and Krueger, 2002) and, more recently, regression discontinuity designs (Hoekstra, 2009; Saavedra 2009; Öckert, 2010). Most of these studies have found that estimates that ignore the problem of selection on unobservables are biased upwards and some find no evidence of a selectivity/"quality" premium at all (Dale and Krueger, 2002; Öckert, 2010; Dale and Krueger, 2011) - leaving ambiguity as to the true effect of university selectivity on earnings.

The present chapter adds to this debate by exploiting data on applications and admissions to university in the UK. In the UK, all full-time undergraduate students apply to university through a centralised applications system (Universities and Colleges Admissions Service, or UCAS) and are allowed to express a fixed number[28] of institution/subject choices on their application form. Once institutions have responded to these choices, applicants are asked to confirm only one firm (or preferred) and one insurance choice from among the offers they received. Importantly, the offers made by institutions are often conditional on the candidate achieving certain grades in their school-leaving exams, and the offer which is ultimately taken up by the candidate (firm or insurance) is determined by his/her performance in those examinations. Individuals who fulfil the conditions set out in their firm offer are under a contractual obligation to attend their firm offer institution (they cannot decide to attend their insurance institution instead). Similarly, individuals who fail to meet the conditions of their firm offer cannot attend that institution and have to attend their insurance institution (provided they meet the conditions set by that institution).

The main identification strategy used in this chapter consists in exploiting within-group differences in institution attended by individuals who expressed the same firm and insurance university choices, where variation in institution attended is driven by whether or not individuals meet the conditions set out in their firm offer. By grouping individuals with the same firm and insurance choices one is able to capture important information about some of the unobservable characteristics which may have contributed to a non-random sorting of individuals across institutions: individuals within the same firm/insurance group will have been deemed to meet similar minimum requirements by the admission tutors who made them the offer (who may have based their decisions on

[28] This was six until 2007/08, and reduced to five thereafter.

information unobservable to the econometrician) and these individuals will also have expressed the same institution preferences based on a comparable underlying utility-maximising function.

Although controlling for firm/insurance group fixed effects will address much of the selection on unobservable student ability and preferences at the application and admission stages, it does not address the observable selection that occurs within groups based on final grades ("tariff score"[29]): students who make the conditions of their firm offer will typically have higher grades than students who did not. Left unaddressed, this would leave an important source of estimation bias, because students with a higher tariff score would also be expected to have higher earnings in the labour market. By including a function of grades in the regression model, I am also able to address this selection at the enrolment stage.

The strategy used in this chapter is closely related to that employed by Dale and Krueger (2002) who compare individuals who applied to, and were accepted by, similar colleges in the US. As argued by them, this approach addresses "selection on observables and unobservables" since "information on the unobservables can be inferred from the outcomes of independent admission decisions by the schools the student applied to". Although Dale and Krueger are able to address selection issues at both the application and admission stages, they have to assume that students randomly select the school they attend from the ones that accepted them (i.e. that there is no further selection at the enrolment stage). As they admit themselves, this assumption is unrealistic[30] and, importantly, they find that take-up of the most selective offer is non-random, with the brightest students significantly more likely to attend the most selective college to which they were admitted.

In the approach presented here, selection at the enrolment stage can also be addressed because: (i) we observe individuals' institutional preferences; (ii) the institution attended is determined by whether or not the applicant meets the conditions set out in their preferred offer; and (iii) we can control for the grades achieved by applicants. One

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[29] In the UK, the grades achieved by individuals in their qualifications prior to entering higher education are converted into a single score called the UCAS tariff. This is a system which permits different qualifications to be compared and can be used by universities in setting entry requirements and making conditional offers to candidates.

[30] One important reason why this assumption will be unrealistic is that in the US institutions use financial aid packages to lure high ability students. In the UK, during the period covered by my dataset, the price of higher education for an individual was the same, regardless of which institution he or she would have attended.

drawback of the methodology used in this chapter, however, is that we have to rely on functional form assumptions about how tariff scores enter the equation to identify the effect of university selectivity on earnings (although robustness checks suggest that the results are not sensitive to such functional form assumptions).

This chapter brings an original contribution to the literature on returns to university selectivity in a number of ways. It is the first paper which attempts to tackle the issue of selection on unobservable characteristics in the context of the UK. In doing so, it exploits a new, previously unavailable dataset and presents a novel methodology for evaluating the impact of selectivity on earnings. In addition, the chapter analyses what types of bias are important in estimating the returns to university selectivity, and it looks at the impact of attending a more selective institution on range of non-pecuniary career satisfaction outcomes.

The results of the analysis indicate that one standard deviation increase in selectivity of the institution attended leads to an increase in earnings of around 7.0% three and a half years after qualifying. This is in line with previous findings for the UK.

The remainder of this chapter is structured as follows. Section 3.2 formally discusses the problem of selection on unobservable characteristics. Section 3.3 provides some background information on the institutional setup in the UK and explains how its unique features can be exploited to provide a new methodology for analysing the relationship between university selectivity and earnings. Section 3.4 describes the data and section 3.5 presents the results. Section 3.6 concludes and contextualises the findings of the chapter by comparing them to those obtained by other authors.

3.2. The Selection Problem

Estimating the returns to institutional selectivity is non-trivial because students are matched to institutions in a non-random way. Selection may occur: (i) at the application stage (students choose to apply to certain universities and not to others); (ii) at the admissions stage (admission tutors take decisions to accept some students and not others); and (iii) at the enrolment stage (applicants decide on the final institution to attend from among the offers they received).

The non-random selection into universities would not be an issue were it to be based entirely on observable characteristics. A problem arises because the selection may be based on non-observable characteristics and those characteristics might themselves be correlated with earnings. Consider a student who was admitted to a prestigious university because of the strong charisma he/she showed at a selection interview. That same character trait may also help that individual obtain a better paid job upon graduation. An econometrician comparing this student to another with the same observable characteristics (e.g. prior attainment, gender, ethnicity, etc...) who attended a different university would wrongly attribute the difference in earnings to the institution attended when, in fact, the true cause is the difference in charisma (which is unobservable to the econometrician).

The problem can be described more formally as follows. Assume that the true relationship between earnings and institutional selectivity is:

$$ln\ W_i = \beta_0 + \beta_1\ SELECT_u + \beta_2\ \mathbf{x_i} + \beta_3\ \mathbf{z_i} + \varepsilon_i \qquad (3i)$$

Where $ln\ W_i$ represents log wages, $SELECT_u$ is a measure of the selectivity of the institution attended[31], $\mathbf{x_i}$ and $\mathbf{z_i}$ are vectors of applicant characteristics, and ε_i is an individual error term. In this equation, the coefficient of interest is β_1, which represents the return to institutional selectivity. However, if because of data limitations the researcher is forced to estimate the following equation (which omits part of the applicant characteristics, $\mathbf{z_i}$), then the estimates of β_1 will be biased and inconsistent if $\mathbf{z_i}$ is also correlated with $SELECT_u$:

$$ln\ W_i = \beta_0 + \beta_1\ SELECT_u + \beta_2\ \mathbf{x_i} + \varepsilon_i \qquad (3ii)$$

As mentioned in the introduction, a range of techniques have been proposed in the literature to address the issue of selection on unobservable characteristics – without clear conclusion emerging so far on the true relationship between earnings and university selectivity. In the next section, I describe how the peculiarities of the UK university system can be exploited to provide a novel approach for looking at this problem.

[31] In practice, I will define institutional selectivity as the average tariff score of entrants to full-time undergraduate courses in the years 2002/03, 2003/04 and 2004/05, respectively. The choice of years coincides with the time period during which the undergraduates in the dataset were at university. The final measure of institutional selectivity is then arrived at by taking the average of the figures for the three years, and standardising it to have mean zero and standard deviation one.

3.3. Methodology

All applicants to full-time undergraduate courses in the UK must apply through a centralised application system (UCAS), of which nearly every university is a member. Applicants complete a standardised application form and are allowed a fixed number of institution/course choices, in no particular order of preference. UCAS then processes these applications and sends them on to the relevant institutions. All choices expressed by the candidate are confidential during the application process, so universities considering an application cannot see any of the candidate's other choices. Institutions then proceed to decide whether or not to make the candidate an offer. These offers can either be conditional (i.e. dependent on future examination performance) or (more rarely) unconditional. In the data used for this analysis (described in section 3.4 below), 69% of all choices expressed by candidates received a conditional offer, and only 10% received an unconditional offer. 18% of applications were rejected by the institution, and another 2% were withdrawn by the candidate before the institution took a decision.

Once applicants have received responses from all the institutions applied to, they must reply by accepting up to two choices: one firm acceptance and one insurance acceptance. The remainder are declined. The firm acceptance is the candidate’s first choice – i.e. their preferred choice out of all of the offers they have received. If candidates accept an unconditional offer, then they are agreeing that they will attend the course at that university or college, so they have to decline any other offers. If they accept a conditional offer, they are agreeing that they will attend the course at that university if they meet the conditions of the offer.

When accepting a conditional offer, candidates can also accept another offer as an insurance choice. The insurance choice can be conditional or unconditional and acts as a back-up to the firm choice. So if the candidate does not meet the conditions for his/her firm choice, but meets the conditions for his/her insurance choice, he/she is committed to that course. If candidates get the grades for both their firm and insurance acceptances, they cannot choose between them: their insurance choice is automatically declined and offered to someone else. So candidates can no longer choose which institution they want to attend after they have received their grades.

This institutional set-up provides an interesting avenue for exploring the effect of university selectivity on graduate earnings because, once universities have made their admission decisions and individuals have declared their institutional preferences, the university that an applicant ultimately attends will depend exclusively on the grades he/she obtains at the end of secondary school – i.e. selection at the enrolment stage can be addressed. Moreover, a meaningful comparison can be made between individuals who expressed the same firm and insurance offers because they will share a range of common characteristics: admission tutors will have deemed them to be of similar potential and the fact that these individuals have expressed the same institutional preferences suggests overlap in their underlying utility-maximising functions. In fact, by pooling individuals with the same firm and insurance offers and exploiting within-group differences in university attended, we are able to remove a considerable portion of the selection on unobservable characteristics which might otherwise bias the estimates of institutional selectivity on earnings. The model estimated is then:

$$ln\ W_i = \beta_0 + \beta_1\, SELECT_u + \beta_2\, f(TARIFF_i) + \beta_3\, \boldsymbol{x_i} + \textstyle\sum_g \delta_g D_{gi} + \varepsilon_i \qquad (3iii)$$

Where, as before, $ln\ W_i$ represents log wages, $SELECT_u$ is a measure of the selectivity of the institution attended, $TARIFF_i$ is the tariff score achieved by the individual in his/her secondary school examinations, $\boldsymbol{x_i}$ is a vector of (observed) characteristics of the individual, and ε_i is an individual error term. Finally, the dummy variables D_{gi} indicate groups of individuals who expressed identical firm and insurance offers. So the model exploits variation in selectivity of institution attended within groups of individuals with the same firm and insurance offers, where this variation is driven by whether or not candidates achieved the grades required by their preferred institution.

Although conditioning on the firm/insurance groups will tackle selection on unobservable characteristics at the application and admission stages to university, it will not address the final selection which occurs at the admission stage and which is driven exclusively by grades achieved. This is why we include in our model a function of tariff score. This inclusion is crucial, and it is what enables us to say something about the counterfactual. By definition, individuals who fulfil the conditions set out in their firm offer will have higher grades than those who fail to do so. By conditioning on tariff score, however, we are able to make inferences about what someone who attended a less selective university would have earned had he/she attended a more selective one.

Because we do not observe the actual offers made by institutions, the above set-up is not a regression discontinuity design. It can, however, be thought of as a difference-in-differences strategy. In essence, we are comparing two individuals with the same firm/insurance offers, one enrolling at the first choice university and the other at the insurance choice institution, to two other students with the same tariff score (or score difference) who had different offers, but both enrolled at the first choice institution. Under the assumption that the selection bias is the same for these two control students, this identifies precisely the university selectivity effect.

Although this setup provides a novel way to explore the effect of university selectivity on earnings, it does suffer from a number of caveats. One, already mentioned, is the reliance on functional form assumptions to identify the effect of selectivity on earnings. To test the sensitivity of the results to these assumptions, a number of functional forms are experimented with including: linear, quadratic and cubic – but higher level terms (quadratic and cubic) are found to be small in magnitude and never statistically significant.

A second limitation is that individuals apply not just to an institution, but also to a particular department/course at that institution. The identification strategy groups and compares individuals with identical institutional preferences but, within those groups, individuals may still make different course choices. Previous papers have rarely been able to address this issue. Although it does not tackle the potential problem of selection into subjects based on unobservable characteristics, subject studied is included as a right-hand side variable to control for earnings differentials related to course of study.

A third issue is that the tariff score is not a perfect measure of prior attainment. Although some courses simply ask for a generic combination of grades (e.g. an A and two B's) regardless of the subject these are in, many (particularly languages, sciences or those with a strong mathematical content) will also require the candidate to achieve a certain grade in a specific subject (e.g. an A and two B's, with a B in mathematics)[32]. Although the dataset contains the overall tariff score achieved by the individual, it does not provide information on the subject of qualifications taken, nor on the specific grades achieved in them. This creates a potential problem because two candidates might have obtained the same point score, but one might have achieved a B in mathematics, whereas the other did not. If a condition of acceptance to the course was a B in mathematics, then the tariff score on its own would fail to capture the difference between the candidate who was accepted onto the course and the candidate who was

[32] To provide the reader with a sense of the types of offers made by universities, Annex 3A contains a summary of entry requirements to full-time degree courses at Royal Holloway, University of London, as recorded on the UCAS website.

rejected. This would be a problem in particular if students with better mathematics skills earn more in the labour market regardless of the institution attended (see Dolton and Vignoles, 2002). In this case, the inability to control for specific subject grades could lead to some upward bias in the in the estimate of returns to selectivity.

Going in the other direction, however, some downward bias is likely to be introduced into the estimates by the fact that most undergraduates who go on to do doctoral studies will be excluded from the analysis[33]. Recent research (Sutton Trust, 2010) has shown that students from leading research universities make up the majority of PhD students and that postgraduates completing a PhD earn on average 23% more than a university graduate.

There are two further sources of potential bias:

(1) We do not observe the actual offer made by the institution and, in particular, whether individuals applying for the same course at the same university receive different offers or not. This would be a problem because the identification strategy relies on the variation in institution attended to be driven by differences in tariff scores, and not by differences in offers received. Take two observationally identical individuals, where one is more motivated than the other, and where this higher motivation also leads to higher wages in the labour market. If the more motivated individual receives a lower offer from the institution and is accepted, whereas the second individual (with identical tariff score but with a more difficult offer) is not, then the estimate of the effect of attending that institution will be biased upwards. Note, however, that this would not present a threat to the identification strategy if offer-making behaviour were similar across institutions and, in particular, across institutions of different selectivity. In addition, institutions publish detailed information about the typical grades required for particular courses. Although this is no guarantee that the offers themselves do not vary by candidate, it does at least suggest the existence of a minimum threshold for each course/institution which will limit the extent of gaming by institutions.

[33] A handful of students may have completed a PhD in between the time of graduation (2004/05) and the time of the survey (2008/09). However, these students would have had to go straight on to doctoral studies and have completed within three years. It was not possible to check the exact number of students in this situation as the only information we have is whether they have completed a “higher degree by research” which does not necessarily have to be a PhD. There are 25 such students in the main sample used.

(2) A second potential source of remaining bias is that individuals who fulfil the conditions set out in their firm offer are somehow different from those that do not: they may be more motivated or better at performing under exam pressure – and these unobservable characteristics may themselves be correlated with earnings. Because candidates self-select into institutions and admission tutors base decisions on detailed information including personal statements, references and (in some cases) interviews, there is some reason to believe that differences between candidates who actually received an offer will be marginal[34].

Given the data available, it is not possible to test for the extent and/or seriousness of the remaining sources of potential bias mentioned above. However, if such bias were important, then, conditional on tariff scores, we would expect some students to be more likely than others to enrol at their preferred institution. To test for this, the likelihood of enrolment in the preferred university is regressed on a range of observable characteristics, including tariff score. The full results are presented in Table 3B-1 in the annexes, and they are reassuring. The only strong and highly significant predictor of whether or not individuals end up attending their firm offer institution is the tariff score – which is exactly what we would expect/want. Two other indicators (out of a total of 50) are marginally significant: older people appear to be marginally less likely to have to take on their insurance offer. Similarly, individuals who attended a further education college in the two years prior to entering higher education were slightly more likely to enrol in their preferred institutions. In a similar but separate OLS regression (second column of Table 3B-1) I regress earnings on observable characteristics (including institutional selectivity) and do not find any evidence that those who attended further education colleges earn more - which suggests this type of selection is not a major source of bias. Older people, however, do have slightly higher wages. Re-running the analysis on young graduates only does not significantly alter the results obtained in this

[34] A variation of this problem is related to the fact that offers are more often than not based on predicted rather than actual grades. Research by UCAS (BIS, 2011) has found that the reliability of predicted grades is around 50%, with 41.7% of all predictions being over-predicted by at least one grade. In addition, the UCAS analysis suggests that over-prediction is more likely for those from lower socio-economic classes. If, as a result, these applicants are less likely to make the conditions set out in their offer, and they have unobservable characteristics which mean they are likely to earn less in the labour market, than the effect of selectivity on earnings would be over-estimated. Elsewhere, however, I find that those from lower socio-economic classes are no more likely to attend their insurance institution than those from higher socio-economic classes. This suggests that the fact that offers are based on predicted rather than actual grades is not likely to lead to considerable bias in the results.

chapter. Although the evidence presented here is certainly not proof that no selection bias remains in the model, the findings are at least encouraging.

3.4. Data

The dataset used in this chapter consists of 3,537 full-time undergraduates in the UK who left university in 2004/05 and whose earnings were measured in 2008/09. Information on these students was combined from three different sources. The starting point was the second Longitudinal Destinations of Leavers from Higher Education (LDLHE) survey[35] which contains key information on employment status, annual salary, industry and occupation of employment, additional qualifications obtained since graduating, as well as answers to a range of qualitative career satisfaction questions. The LDLHE survey was linked to student university records (held by the Higher Education Statistics Agency, or HESA) through unique identifiers. These records hold information such as the institution attended by individuals, their subject of study and degree attainment. Finally, individuals' application number as recorded on the HESA data was used to link back to administrative records held by UCAS on the their applications to university and institutions' admission decisions. Both the UCAS and the HESA records hold a wealth of socio-demographic information on the individual, as well as his/her tariff score[36].

UCAS data is available for full-time undergraduates only and, because the applications data obtained for this analysis only goes back to 2002 and the LDLHE surveyed the 2004/05 graduating cohort, it was possible only to look at individuals who were on courses of no longer than three years (and took no more than three years to complete)[37]. Although no data was available to estimate the proportion taking longer than three years to complete[38], full-time undergraduate qualifiers on three year-long courses represented 73% of the entire full-time undergraduate qualifier population in the UK in 2004/05.

It is important to emphasise that the final sample used in this chapter is not entirely representative of the target population, and so there may be some issues around the external validity of the results. The main issue is that the LDLHE only has a 26% response rate. In addition, only information on full-time workers is used (74% of the

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[35] For more information about the survey, visit: www.hesa.ac.uk/index.php/content/view/112/154.
[36] See Annex 3C for details on how the final sample was derived.
[37] Note however, that, most undergraduate courses in the UK take three years to complete. Only some courses (e.g. Engineering, Medicine and certain languages) take longer than three years.
[38] A longitudinal HESA dataset with individuals linked over time would be needed for this.

LDLHE sample is in full-time employment) and some individuals (14%) did not respond to the salary question. Finally, the identification strategy used in this chapter requires that individuals express both a firm an insurance choice (55% of full-time undergraduate applicants in 2002 did). Another 1,220 observations were dropped because they did not match to anyone else with the same firm and insurance choices.

Table 3-1 and Table 3-2 below compare the characteristics of the sample with the more general population of 2004/05 full-time undergraduate qualifiers who applied through UCAS and were on courses of a length of three years or less. Table 3-1 shows that the individuals in the sample are more likely to be female, younger, from an ethnic minority background, and from less deprived areas, which is reflected in their higher tariff scores, as well as the more selective institutions they attend. This, combined with the fact that we only observe people who completed degrees within three years, means that there is some bias in the subject representation in the dataset. As Table 3-2 shows, there is a slight over-representation on highly selective courses like Physical Sciences, Law and Historical and Philosophical Studies, and an under-representation on longer courses (like Engineering) or less selective subjects (like Subjects Allied to Medicine and Education). Overall, however, the data still demonstrate a good spread of characteristics and subjects, and 117 out of the 165 higher education institutions in the UK are represented in the final sample.

Table 3-1: Descriptive Statistics – Socio-Demographic Characteristics

	Population Mean ‡	Sample Mean	t Statistic°
% Female	0.57	0.61	4.39
Average Age	22.03	20.53	-32.97
% White	0.82	0.78	-6.20
% Black	0.03	0.05	4.96
% Asian/Chinese	0.09	0.11	4.69
% Mixed Ethnicity	0.02	0.04	6.00
% Unknown Ethnicity	0.04	0.02	-7.81
% IMD Quartile* 1 (most deprived)	0.23	0.20	-4.35
% IMD Quartile 2	0.23	0.21	-2.02
% IMD Quartile 3	0.23	0.22	-1.34
% IMD Quartile 4 (least deprived)	0.22	0.27	6.88
% IMD Unknown	0.10	0.10	0.17
% Disabled	0.08	0.07	-3.10
Average Individual Tariff Score†	208.09	334.73	48.81
Average Quality of Institution Attended	0.16	0.64	27.12
Average Tariff Score of Institution Attended	218.45	268.20	30.13
% Achieving a "Good" Degree	0.56	0.66	12.40
N=	151,324	3,537	

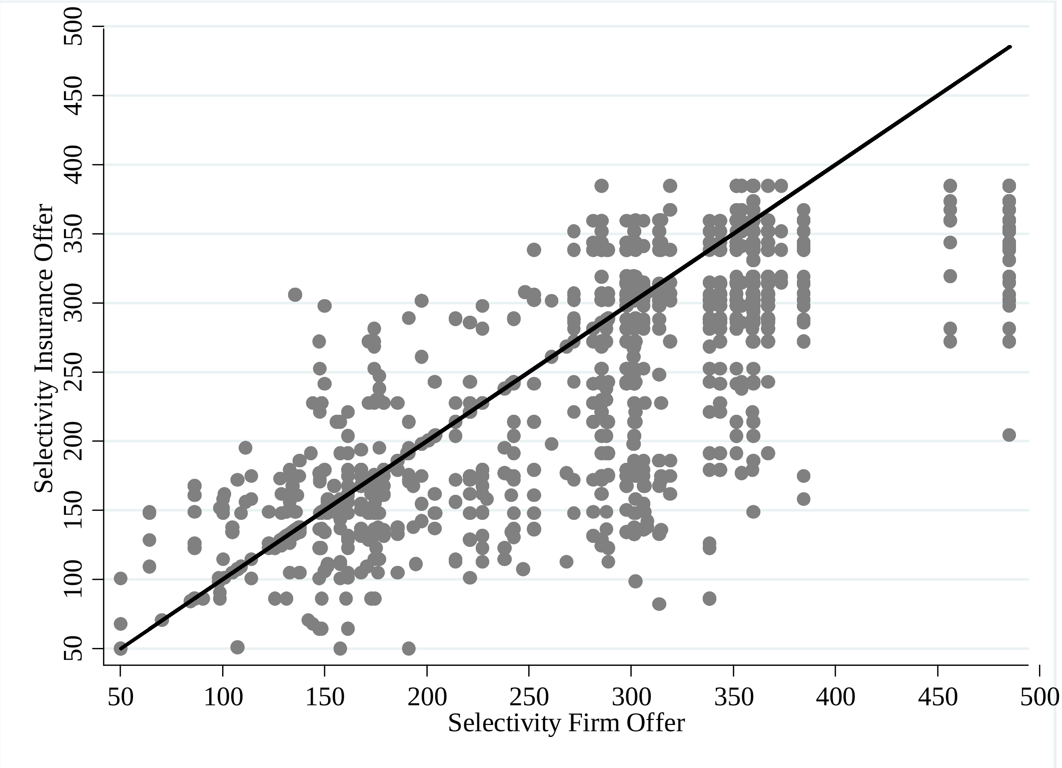
§ The "Population" is defined as qualifiers in the HESA 2004/05 data who were on full-time undergraduate courses of a length of 3 years or less, and who were recorded as having applied through UCAS. In addition only individuals targeted to be part of the 6-months Destinations of Leavers from Higher Education survey have been included. Individuals with missing tariff scores are excluded.
* IMD quartile is assigned based on the entire population.
† Tariff score in this table is taken from the HESA record because it was available for the entire population. Tariff score elsewhere in this chapter is taken mainly from the UCAS data as it is more reliable.
° t Statistic of the difference between the sample and population means.

Table 3-2: Descriptive Statistics – Subject of Study

Subject Group	Population	Sample	t Statistic
Medicine and Dentistry	0.2%	0.7%	3.48
Subjects Allied to Medicine	5.3%	3.9%	-4.28
Biological Sciences	10.4%	12.6%	3.80
Veterinary Sciences, Agriculture and Related Subjects	1.0%	0.7%	-2.29
Physical Sciences	3.9%	6.3%	5.96
Mathematical and Computer Sciences	5.9%	9.1%	6.55
Engineering	2.5%	2.2%	-1.27
Technologies	0.5%	0.1%	-7.43
Architecture, Building and Planning	1.3%	1.2%	-0.27
Social Studies	9.6%	11.6%	3.59
Law	5.0%	6.9%	4.44
Business and Administrative Studies	9.7%	10.6%	1.70
Mass Communications and Documentation	3.7%	2.2%	-6.07
Linguistics, Classics and Related Subjects	4.6%	5.5%	2.42
European Languages, Literature and Related Subjects	0.1%	0.0%	-2.48
Eastern, Asiatic, African, American and Languages	0.2%	0.0%	N/A
Historical and Philosophical Studies	5.6%	7.0%	3.09
Creative Arts and Design	12.8%	3.4%	-30.52
Education	2.6%	1.7%	-4.23
Combined Social Sciences	0.6%	0.9%	2.35
Combined Sciences	1.4%	2.0%	2.49
Combined Arts	4.7%	3.1%	-5.71
Social Sciences Combined with Arts	3.4%	3.6%	0.64
Sciences Combined with Social Sciences	4.8%	4.6%	-0.37
General, Other Combined and Unknown	0.4%	0.4%	-0.39

Figure 3-1 shows the selectivity of firm and insurance choices of the individuals in the sample. As the graph illustrates, applicants tend to choose firm and insurance institutions of different selectivity (85% of applicants), and the majority (60%) pick a firm choice which is more selective than their insurance institution. For the identification strategy used in this chapter, it does not matter which of the institutions is the most selective – as long as there is variability in selectivity between the firm and insurance choices of applicants. Note, also, that the most selective institution need not be the one making the candidate the most difficult offer.

Figure 3-1: Selectivity of Applicants' Firm and Insurance Choices



Overall, individuals who attend their firm choice institution attend more selective institutions (272 average tariff score of entrants, compared to 235 for those attending their insurance institution). In addition, individuals who attend their firm choice institution have higher prior attainment on average (342 tariff points, compared to 301 for those who attend their insurance institution) – confirming that candidates who miss out on their firm choice do so because they do not make the grades asked for in their preferred offer.

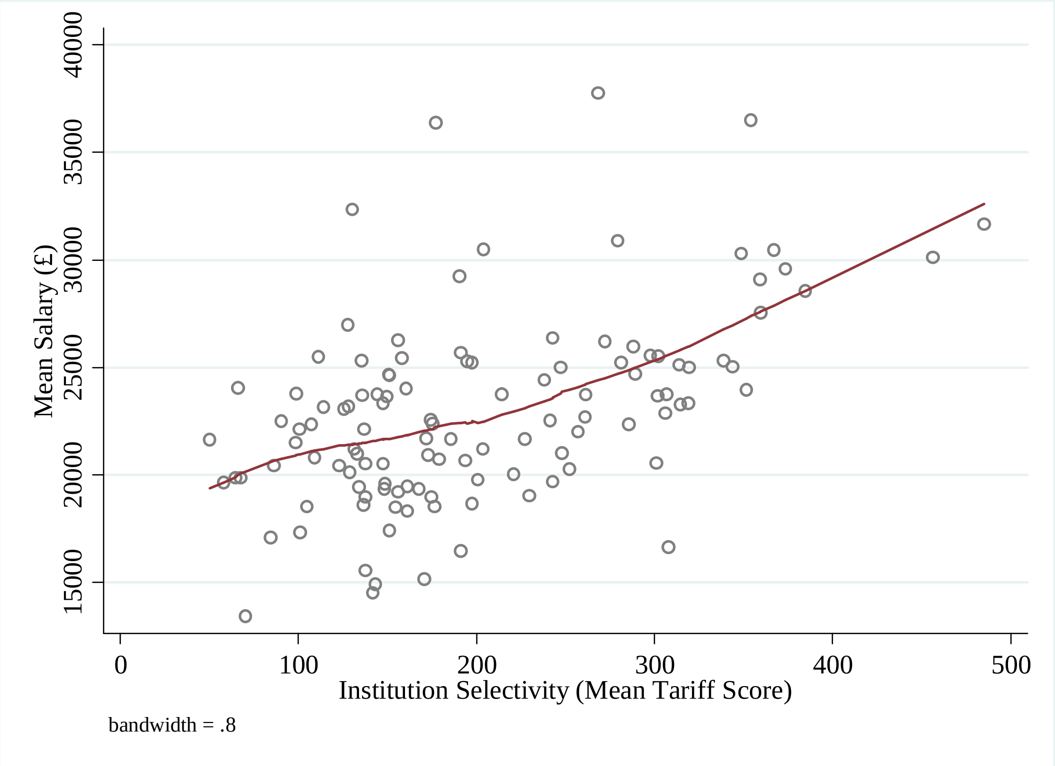
Key to the identification strategy used in this chapter is that there is variability in institution attended within groups of individuals with the same firm and insurance offers. The 3,537 observations in the sample can be split into 837 groups of individuals with the same firm and insurance choices. In 230 of these groups, individuals attend institutions of different selectivity (totalling 1,393 observations). The average spread in selectivity of institution attended amongst these 230 groups is 84 tariff points.

3.5. Results

3.5.1. Earnings

Figure 3-2 illustrates the relationship between institutional selectivity and the mean earnings of graduates three and a half years after graduation, using locally weighted regression. It is clear from the upward slope that higher institutional selectivity is related to higher earnings in the labour market.

Figure 3-2: Relationship between Mean Graduate Earnings and Institutional Selectivity



Notes: the graph shows the relationship between institutional selectivity and average salary of graduates three and a half years after graduating using locally weighted regression. The graph is done at the institutional level, so each circle represents an institution.

This is confirmed by the results in row (i) column (i) of Table 3-3, which shows the unconditional relationship between earnings and institutional selectivity: a one standard deviation increase in the selectivity of institution attended increases earnings by 9.7% three and a half year after qualifying.

Table 3-3: Main Results – Effect of Selectivity and Quality on Earnings

		(i)	(ii)	(iii)	(iv)
(i)	**Selectivity**	0.0971	0.0830	0.0705	0.0696
		(0.0101)***	(0.0136)***	(0.0140)***	(0.0135)***
	N	3537	3537	3537	3537
(ii)	**Quality**	0.113	0.0646	0.0534	0.0501
		(0.0113)***	(0.0124)***	(0.0127)***	(0.0119)***
	N	3537	3537	3537	3537
	Firm/Insurance Group Fixed Effects	no	yes	yes	yes
	Tariff Score	no	no	yes	yes
	Additional Controls†	no	no	no	yes

Standard errors in parentheses, clustered at the institutional level.

* p<0.05 ** p<0.01 *** p<0.001

† Additional controls include: number of choices; socio-demographic information (gender, ethnicity, area deprivation measures, socio-economic class, age, month of birth, disability status, domicile, and type of institution attended prior to starting their undergraduate course); subject and level of qualification achieved; degree class attained; term-time accommodation; subject and level of any additional qualifications attained since graduating; and an indicator for whether the individual is studying alongside work[39].

Row (i) column (ii) estimates the effect of selectivity within groups of individuals who had identical firm and insurance offers. This estimate can be thought of as addressing selection at both the application and admission stages. The point estimate is 15% lower than the one presented in the first column, with a standard deviation in selectivity leading to an 8.3% increase in earnings three and a half years after graduation. Adding the tariff score[40] (column (iii)) addresses selection at the admission stage and reduces the estimate by a further 15% - suggesting that selection at the admission stage is significant and should not be left unaddressed. The final column adds a range of control variables, which barely affects the coefficient – suggesting that estimating the effect of selectivity within groups of individuals with the same firm and insurance offers whilst controlling for tariff scores adequately tackles selection into institutions. The final estimates suggest that a standard deviation increase in selectivity leads to a 7% increase in earnings three and a half years after graduation.

[39] Some of these control variables (e.g. degree attainment and additional qualifications obtained) may be considered endogenous. Regressions excluding these variables lead to almost identical findings.

[40] This model also includes an indicator in case the tariff score is missing, which is the case for around 13% of individuals in the sample. Rerunning the analysis on a sample excluding individuals with missing tariff scores leads to very similar results to the ones presented in Table 3-3.

To compare the results with previous estimates obtained for the UK, the models are also re-run using a measure of institutional "quality" instead of selectivity. The university "quality" index is constructed using five indicators: university selectivity; expenditure per student; the ratio of academic staff to the number of students; the non-continuation rate; and the number of applications per accepted applicant[41]. These are averaged across the three years 2002/03, 2003/04 and 2004/05, standardised to have mean zero and standard deviation one, and combined into a single measure using factor analysis[42]. Although we will refer to this measure as an indicator of "quality", it is really more appropriate to think of it as the institution's position in university league tables.

The results of the analysis using the quality measure are presented in row (ii) of Table 3-3. Once again, these estimates show that selection at all three stages (application, admission and enrolment) is significant, and that adding controls for observable characteristics has a relatively small effect on the estimates. The quality models suggest that a standard deviation increase in the "quality" of institution attended leads to an increase in earnings three and a half years after graduation of around 5%. This is very much in line with previous estimates obtained for the UK: e.g. Hussain et al (2009) conclude that a standard deviation rise in university quality leads to an increase in earnings of around 6% (at a point in time after graduation similar to the one considered in this chapter)[43].

As a further robustness check on the results obtained in Table 3-3, a series of alternative models were run similar to the ones in Dale and Krueger (2002) which compare individuals who applied to, and were accepted by, institutions of comparable selectivity. In practical terms, "similar" institutions are defined as institutions that are in the same

[41] All of these are publicly available. Total institutional expenditure and the number of academic staff are published annually by HESA in their "Resources of Higher Education Institutions" publications. The total of number of students is again published by HESA in their "Students in Higher Education Institutions" publication. The non-continuation rates are published by HESA in their annual "Performance Indicators in Higher Education in the UK". The non-continuation rates track students in the year they enter an institution to the following year and provide information about whether the student is still in HE the following year or not. I use the non-continuation rates of young full-time first degree entrants. Finally, information on applications and acceptances by institution are published annually by UCAS on their website.

[42] Basic summary statistics for the five components of the quality measure (averaged across the three years, but not standardised) are presented in annex Table 3D-1, and Table 3D-2 shows the correlation matrix of all the individual measures (standardised) as well as the single measure of university quality derived from the factor analysis.

[43] Chevalier and Conlon (2003) estimate that graduating from a Russell Group institution adds up to 6% to a male graduate's earnings compared to graduating from a modern university, and 2.5% for women. Chevalier (2009) finds that a graduate from a top department will earn up to 7% more than a similar graduate from the lowest quality department.

quantile of selectivity (models are run with 2, 4, 8, 16, 32 and 64 quantiles, respectively). In the simplest case, this means that institutions are divided into two groups (high versus low selectivity) and individuals matched based upon whether they applied and were accepted to institutions from the top/bottom half in terms of selectivity. There are 145 different institutions in the sample so, in the most elaborate model, this means that there are 145/64 (i.e. around two) institutions per selectivity grouping. I also run a model where individuals are matched on the exact institutions that they applied to and were accepted by.

The advantage of these models is that they are less demanding from a data perspective, so sample sizes tend to be larger. On the downside, these models offer less convincing strategies to tackle the problem of selection on unobservable characteristics. More detail and the results can be found in Annex 3E. To summarise, these models produce results very similar to the ones presented in Table 3-3, with a standard deviation in institution selectivity leading to an increase in earnings three and a half years after graduation of between 3.6% and 5.8%.

3.5.2. Non-Earnings Outcomes

Besides information on employment and earnings, the LDLHE survey also contains information from a number of qualitative questions asked to the respondents regarding their current job and how satisfied they are with their higher education course. This section explores how the selectivity of the institution attended affects the response to five of these questions: (i) whether graduates are currently in a job for which their qualification is a formal requirement; (ii) whether the current job is the type of work they wanted; (iii) whether, with hindsight, they would have studied at a different institution; (iv) whether they are satisfied with their career so far; and (v) whether they think their university education was value for money.

The results of this analysis are presented in Table 3-4. Each row in this table is for a different outcome (described in detail in the notes below the table). The columns are as in Table 3-3: column (i) shows the unconditional relationship between the outcome and institutional selectivity; column (ii) adds firm/insurance group fixed effects; column (iii) adds tariff score controls; and column (iv) includes a range of controls for observable characteristics.

Table 3-4: Effect of Selectivity on Non-Earnings Outcomes

		(i)	(ii)	(iii)	(iv)
Outcome					
	Formal Requirement°	0.0961	0.0662	0.0374	0.0463
		(0.00788)***	(0.0201)**	(0.0212)	(0.0253)
	N	3537	3537	3537	3537
	Dream Job†	-0.00393	-0.00796	-0.0141	-0.0287
		(0.00754)	(0.0224)	(0.0235)	(0.0250)
	N	3537	3537	3537	3537
	Different Institution‡	-0.0762	-0.0813	-0.0884	-0.0766
		(0.00766)***	(0.0190)***	(0.0198)***	(0.0225)***
	N	3537	3537	3537	3537
	Satisfied§	0.00812	0.000671	0.00572	0.0165
		(0.00733)	(0.0228)	(0.0229)	(0.0264)
	N	3537	3537	3537	3537
	Value for Money‖	0.0353	0.0339	0.0380	0.0458
		(0.0174)*	(0.0209)	(0.0200)	(0.0202)*
	N	3537	3537	3537	3537
	Firm/Insurance Group Fixed Effects	no	yes	yes	yes
	Tariff Score	no	no	yes	yes
	Additional Controls	no	no	no	yes

Standard errors in parentheses are clustered at the institutional level.

* p<0.05 ** p<0.01 *** p<0.001

° Formal Requirement: question asked was: "As far as you are aware, [was the type of qualification you obtained] important to your employer when you gained this employment?" and possible answers were: "Formal requirement", "Important", "Not very important but helped", "Not important", "Don't know". The outcome variable in this regression is a dummy variable equal to one when the respondents ticked the first of these answers ("Formal Requirement").

† Dream Job: question asked was: "Why did you decide to take the job you were doing on 24 November 2008?" A range of options were given (and more than one could be ticked), one of which was "It was exactly the type of work I wanted". The outcome variable in this regression is a dummy variable equal to one if the respondent ticked this answer.

‡ Different Institution: question asked was: "If you were now to choose whether or not to do the course leading to the qualification you obtained in 2004/05, how likely or unlikely is it that you would study at a different institution?" Possible answers were: "Very likely", "Likely", "Not very likely", "Not likely at all", "Don't know". A dummy variable was set to one if the respondent ticked either one of the first two of these answers.

§ Satisfied: question asked was: "How satisfied or dissatisfied are you with your career to date?" with a response scale ranging from "Very satisfied" to "Not at all satisfied". The outcome variable in this regression is a dummy variable set to one if the respondent was very satisfied.

‖ Value for Money: question asked was: "How far do you agree or disagree with the statement about your overall experience of the course you completed in 2004/05: "My course was good value for money"?" The answers were on a five-point scale from "Strongly agree" to "Strongly disagree". If respondents strongly agree, then the dummy outcome variable in this regression was set to one.

The results indicate that people who attended more selective institutions are less likely to say that they would study at a different institution if they could do it all over again, and more likely to say that their course was value for money. By contrast, the selectivity of the institution attended appears to have very little impact on whether or not individuals are currently in a job for which their qualification is a formal requirement, or which they consider to be exactly the type of work they wanted. Similarly, there appears to be no effect on the likelihood of being satisfied with one's career to date.

3.5.3. Non-Linearity

A number of recent papers have explored the issue of non-linearity in the return to institutional selectivity/"quality" – i.e. whether institutional selectivity matters more at one end of the distribution than at the other. The general methodology employed is to replace the continuous measure of selectivity/"quality" by dummies indicating which quartile of the distribution the institution belongs to. The question is then how much more individuals who attended an institution in the second, third or fourth quartiles earn than those who attended an institution in the first quartile (the omitted category). Using this approach, Black et al (2005) find "some evidence of non-linearities in quality, with little gain from moving from the 1st to the 2nd quartile and relatively large gains associated with moving from the 3rd to the 4th quartile", and Hussain et al (2009) conclude that "the relationship between university quality and wages is highly non-linear, with a much higher return at the top of the distribution." Although employing a slightly different methodology, Chevalier (2010) draws essentially the same conclusions.

Table 3-5 below shows how the results obtained in Table 3-3 change when the continuous measure of selectivity is replaced by dummy variables indicating quartiles of institutional selectivity.

Column (i) shows that the raw relationship between institutional selectivity and earnings is highly non-linear, with no return to attending an institution in the second or third quartiles of selectivity (as opposed to attending one in the first), but a very large return to attending an institution in the top quartile. These results are comparable to those found elsewhere in the literature. As soon as firm/insurance group fixed effects are introduced, however, this non-linearity disappears. Looking at the preferred model in column (iv) - which also includes controls for tariff score and other observable characteristics - we find that there are considerable returns to attending institutions in the second and third quartiles as opposed to an institution in the bottom quartile.

Table 3-5: Non-Linearity in the Return to Institutional Selectivity

	(i)	(ii)	(iii)	(iv)
Quartile 2	-0.00407	0.109	0.113	0.126
	(0.0317)	(0.0608)	(0.0580)	(0.0507)*
Quartile 3	0.0306	0.203	0.193	0.166
	(0.0434)	(0.0511)***	(0.0463)***	(0.0436)***
Quartile 4	0.197	0.119	0.218	0.218
	(0.0353)***	(0.0272)***	(0.0478)***	(0.0478)***
N	3537	3537	3537	3537
Firm/Insurance Group Fixed Effects	no	yes	yes	yes
Tariff Score	no	no	yes	yes
Additional Controls	no	no	no	yes

Standard errors in parentheses. These are clustered at the institutional level.
* p<0.05 ** p<0.01 *** p<0.001

This finding goes against the conclusions drawn in the literature so far. Although it would be premature to conclude that the previous literature is wrong, it does raise the question of whether the methodology used so far to explore non-linearities in the return to institutional selectivity makes sense. Indeed, individuals who attend the bottom quartile of institutions will be very different from individuals who attend the top quartile of institutions, and making direct comparisons between them may be invalid. Instead, the approach proposed here (comparing individuals with the same firm and insurance choices) compares individuals who could have attended both sets of institutions. When comparing individuals with the same firm and insurance offers, there are relatively few individuals who had a firm offer from a top quartile institution and an insurance offer from a bottom quartile institution (132 in the sample used here) - but this is exactly why the approach used previously in the literature may be flawed, i.e. because there is very little common support for such a model[44].

[44] Note that another limitation of this methodology is that the identification relies on comparing individuals who attended quartile 4/3/2 institutions to those who attended quartile 1 institutions only. So the model does not directly compare individuals who attend, say, quartile 3 versus quartile 2 institutions, or quartile 4 versus quartile 3 institutions. I have experimented with models where the analysis is re-run

3.6. Conclusion

The results in this chapter suggest that it pays to attend more selective institutions. As mentioned above, these findings are similar to those found in previous studies for the UK. Most other studies in the US and elsewhere have also found positive returns to institutional selectivity/“quality”. The results obtained in this chapter even appear small in comparison to some recent estimates for the US and Columbia, where attending more selective institutions has been estimated to increase earnings by 20 to 25% (Hoekstra, 2009; Saavedra, 2009).

Yet three important studies have found no evidence of such a premium: Dale and Krueger (2002) conclude that “students who attended more selective colleges earned about the same as students of seemingly comparable ability who attended less selective schools”, Öckert (2010) states that his “quality estimates are [not] significantly different from zero” and Dale and Krueger (2011) find again that their “estimates of the return to college selectivity […] are generally indistinguishable from zero.” What explains this discrepancy in findings?

The zero return to institutional quality found in the Öckert paper might be easily explained by the more compressed wage structure in countries like Sweden. The return to education in Sweden has generally been found to be on the low end, and Öckert himself finds no evidence of a return to a college education. Given this, it is perhaps not surprising to find that the selectivity of the college attended plays no role in explaining an individual’s earnings.

The Dale and Krueger (2002, 2011) findings are more difficult to reconcile with the previous literature because, like in the UK, there are significant returns to education in the US. In addition, tuition fees at American universities are high and vary considerably between institutions, reflecting in part the differences in earnings of graduates from different institutions.

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on sub-samples to allow for these more “marginal” comparisons. I have also run a model where I explore non-linearities in the return to institutional selectivity by keeping the whole sample and a continuous measure of selectivity, but also adding in a squared term of selectivity. On the whole, these models are consistent with the results described in the main text. However, given the small sample sizes, results are generally unstable and estimates lack precision. So the main conclusion from this section is not necessarily that there are no non-linear returns to institutional selectivity, but rather that there are significant problems of common support with the main strategy used so far in the literature to explore non-linearities.

One possible explanation might be that Dale and Krueger measure earnings at a much later point in graduates' careers (around the 15-year mark in their 2002 study, compared to three and a half years in this chapter). There is some evidence (Chevalier, 2009) to suggest that the institution you attend may act as a signal to employers (so it gets you higher earnings at the outset), but that the institutional premium wears off over time (Lang and Siniver, 2010). However Dale and Krueger (2011) themselves find that the return to college selectivity increases over the course of a student's career (in models that do not adjust for selection), which appears to discredit this explanation. Perhaps a more plausible explanation for the Dale and Krueger (2002, 2011) findings is that their dataset only covers a narrow group of highly selective colleges covering a limited range of selectivity (Long, 2008), so that the effect of selectivity on earnings may be hard to identify.

Either way, it is important to stress that both the Dale and Krueger papers do find some evidence that the institution you attend matters to your earnings. Dale and Krueger (2002), for instance, find that the school a student attends is systematically related to his or her subsequent earnings in a regression which includes dummy variables indicating the school of attendance. The same paper also finds that there is a substantial payoff to attending schools with higher net tuition, as well as some evidence that expenditure per student also matters to earnings – although these findings are not corroborated by the 2011 study. In both papers, however, Dale and Krueger find that children from low-income/less educated families earn more if they attended selective colleges, and the 2011 study also finds positive returns to selectivity for black and Hispanic students.

Taken together with the other papers cited, the weight of evidence now does appear to point to the existence of a university selectivity premium – at least for certain sub-groups of the student population. An important unresolved issue, however, is the mechanism through which graduate earnings are increased and, in particular, the role of signalling versus that of productivity gains. This remains an important avenue for future research and one with important implications for student choice and university funding.

4. University Rankings: Do They Matter in the UK?

4.1. Introduction

Higher education in the UK (and in England in particular) has become increasingly marketised in recent years. Successive Governments have shifted the burden of costs from the taxpayer onto students and have encouraged more competition between institutions by allowing universities to charge higher fees. £1,000 tuition fees were introduced for home-domiciled students in England following the 1997 Dearing Report. They were increased to £3,000 in 2006/07 and, from 2012/13 onwards, universities will be allowed to charge up to £9,000 a year. More and more, students are expected to act like consumers in a Tiebout model: voting with their feet, and driving up quality and efficiency in the process.

As in any other market, however, competition only works if consumers are well informed. With over half a million applicants each year, 165 higher education institutions to choose from (Universities UK, 2010), and a good as complex as a university education, consumption decisions are likely to be based on imperfect information. In addition, higher education is an experience good, with quality difficult to observe in advance and only really ascertained upon consumption.

Prospective students do not necessarily complain about the quantity of information available, but rather about how that information is presented to them. In particular, with an abundance of data and statistics published from a range of different sources, applicants often find it difficult (and spend a lot of time) finding the information that is useful to them (NUS, 2008). What they need is information in an easily digestible format which allows them to compare institutions in a straightforward way. However, summarising multidimensional information into a single quality measure is a complex process.

In the UK (as elsewhere in the world) third parties (often newspapers) have spotted this gap in the market and have filled it by constructing simple indices composed of a range of indicators purporting to measure university quality: expenditure per student, student/staff ratios, teaching inspection scores, entry qualifications of students, job outcomes of graduates, and other measures. In the US, the most influential university league table is the U.S. News and World Report ranking. In the UK, the most commonly used league tables are the Times Good University Guide and the Guardian

University Guide. These have recently been joined by newer attempts at ranking universities: the Sunday Times and the Independent (the Complete University Guide), and there are now also a number of international rankings, of which the Academic Ranking of World Universities (ARWU, or also known as the "Shanghai Ranking") is probably the most famous. The Times Higher Education (THES) World University Ranking is another.

Whether or not we believe these rankings accurately reflect the quality of education on offer (an issue which has been hotly debated[45]), they are being widely used by applicants to university. In the UK, perhaps 1 in 5 of all applicants believe they are influenced by them, but a much wider group are aware of them (Roberts and Thompson, 2007). In book form, the Times Good University Guide sells over 20,000 copies each year[46] and has significant web and news media exposure (op. cit.). When the result is positive, universities are quick to post the ranking onto their websites in an attempt to attract applications from prospective students.

However, despite the large number of users and anecdotal evidence on their impact on both applicants and institutions, there has been very little systematic analysis in the UK of the effect league tables have on the higher education sector. This is in contrast with the US, where a large volume of papers have argued that college rankings do impact on institutions and students (see section 4.2 below). In the UK, the little evidence that does exist (Elliott and Soo, 2010; Soo, 2011) suggests that league tables have either little or no impact on the number of applications received by universities.

This chapter contributes to the literature by offering a more comprehensive analysis of how changes in rankings are related to changes in applicant and university behaviour in the UK. The impact of four of the most influential league tables on a wide range of outcomes is analysed: the number of applications received by institutions, the proportion of applications which are successful, the average entry qualifications of applicants and accepted applicants, and the socio-demographic make-up of universities' applicant pools (including age, gender, ethnicity and socio-economic class). In addition, the impact of rankings on attracting overseas students to the UK, as well as on the fees

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[45] See, for instance: Provan and Abercromby (2000), Clarke (2002), Eccles (2002), Yorke and Longden (2005), Turner (2005), Dill (2006), and Birnbaum (2007).

[46] This is over and above the general circulation of these newspapers in print. According to recent statistics (Ponsford, 2011), the Guardian newspaper has a circulation of around quarter of a million, and the Times' is just under half a million.

universities are able to charge them, is investigated. The chapter contributes to the wider literature on the impact of league tables on applicants and institutions because, in contrast to the majority of US research which focuses on top and highly selective colleges only, the UK data allows us to look at the entire spectrum of institutions in the sector.

The results obtained in this chapter offer fairly consistent evidence of a relationship between rank changes and applicant behaviour in the UK – although the effects found are modest and suggest that other factors may play a more important role in attracting applicants to institutions. Universities that fall down the rankings experience small but statistically significant drops in the number applications received, as well as in the average tariff score (a summary measure of academic attainment calculated by UCAS) of applicants and accepted applicants. Candidates who react most to a change in rankings tend to be male, young, Asian, high-attaining, from higher socio-economic backgrounds, and from independent schools. As a result, the effect of a change in rankings is found to be more significant for prestigious universities. All of these findings are consistent with those found for the US.

The remainder of this chapter is structured as follows. The relevant literature is reviewed in section 4.2. Sections 4.3 and 4.4 describe the data and methodology used. Section 4.5 summarises the results, and section 4.6 concludes.

4.2. Literature Review

Several papers in the US have explored the effect of rankings (and the U.S. News and World Report rankings in particular) on the behaviour of both applicants and colleges. Monks and Ehrenberg (1999) were probably the first[47] to carry out a systematic empirical investigation of the impact of rankings on potential students and academic institutions. Looking at 30 colleges at the very top of the undergraduate rankings for the 11 years between 1988 and 1999 (i.e. a panel of 330 observations), they used a simple fixed effects model (with year and institution dummies) and found that a fall in rank: increases an institution's admit rate; lowers the proportion of an institution's admitted applicants accepting positions (the yield rate); leads to a decline in the average SAT

[47] Parker and Summers (1993) is an earlier paper which looked mainly at the effect of changes in tuition and fees on the matriculation rate of applicants admitted to a group of selective liberal arts colleges. Although they also look at college rankings, they do not explore the effect of *changes* in rankings. They find that the higher an institution's ranking, the higher its matriculation rate.

score of the institution's incoming freshman class; has no effect on tuition levels; but does decrease the typical expected freshman self-help contribution from students; and hence leads to a reduction in net tuition.

A number of papers have since built on and extended the work by Monks and Ehrenberg by: looking at different rankings (Buss, Parker and Rivenburg, 2004; Griffith and Rask, 2007); updating the analysis with more recent data (Bowman and Bastedo, 2009); extending the sample to include private and other types of institutions (Meredith, 2004; Bowman and Bastedo, 2009); looking at particular subjects (Bednowitz, 2000 looks at Business School rankings; Saunder and Lancaster, 2006 look at Law School rankings); investigating the effect on employers (Bednowitz, 2000); and examining whether rankings affect the public financing of institutions (Jin and Whalley, 2007).

Generally, these papers reinforce the Monks and Ehrenberg results, but a few additional findings are worth noting. Many papers find, for instance, that the effects of rankings are stronger for institutions at the top (Griffith and Rask, 2007; Saunder and Lancaster, 2006) and for private ones (Meredith, 2004). Griffith and Rask (2007) also find that women and minorities appear to be less sensitive, and that aided students have become more sensitive to rankings over time. Meredith (2004) provides some evidence that the socio-economic and racial demographics of universities may be affected by changes in rank.

The use and impact of university rankings in the UK is less well researched. Some surveys have looked at which types of students most use league tables in their higher education choices. Roberts and Thompson (2007) summarise this evidence which suggests that Asians, males, young applicants, those from high income backgrounds and high achievers are amongst the most avid users of rankings information. There is some evidence also that university rankings are important to international students.

Both Abbot and Leslie (2004) and Roberts and Thompson (2007) find that higher ranked institutions in the UK receive more applications, but Elliott and Soo (2010) and Soo (2011) are the only papers I am aware of which explore the effect of a change in rankings on applicant behaviour. Elliott and Soo (2010) look at the impact of the Times Good University Guide on applications from overseas students to Business and Engineering courses over the period 2002 to 2007. They find that Business Studies students and female Engineering students are influenced by the overall ranking of the university, and that Business Studies (but not Engineering) students also consider the subject-specific rankings of universities. Soo (2011) uses 2005-2009 data to investigate the impact of the Sunday Times league table on applications to university. The author finds that the overall ranking has no impact on home, EU or overseas applications, but that it does have some effect on EU student applications to pre-92 universities[48]. He also finds that better research quality is associated with more home and EU applications in post-92 institutions, while it is weakly associated with fewer applications from home students in pre-92 universities.

This research on the impact of league tables on applicants and institutions sits within a wider literature on the impact of information disclosure on consumer/producer behaviour. Remaining within the sphere of education, many papers have documented how the provision of information to parents affects school choice (Hastings and Weinstein, 2007; Hastings and Weinstein, 2008; Koning and van der Wiel, 2010) and how publishing school performance information improves test scores (Canoy and Loeb, 2002; Hanushek and Raymond, 2004; Dee and Jacob, 2009; Burgess, Wilson and Worth, 2010) as well as schools' instructional policies and practices (Rouse et al, 2007). Similarly, within the field of health economics, a well-developed literature has explored the impact of information about health care services and quality on patient choice. See, for instance: Wübker, Sauerland and Wübker (2008), Culler, Huckman and Landrum (2004), Chernew, Gowrisankaran and Scanlon (2008).

More generally, and to quote Dranove and Jin (2010): "literally from cradle to grave, consumers rely on quality disclosure to make important purchases" – where quality disclosure is defined as “an effort by a certification agency to systematically measure and report product quality for a nontrivial percentage of products in a market”. In the case of higher education, the attempt by newspapers (and/or other entities) to measure university quality, rank institutions and disseminate such information in an easily understood format to aid prospective students in their decisions about which institutions to attend, is a clear case of “quality disclosure”. The present chapter thus sits within a wider literature on the effect of information provision on consumer demand.

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[48] In 1992, many polytechnics and colleges of higher education were given university status in the UK. The term “pre-1992” therefore refers to institutions that already had university status prior to that date.

4.3. Data

The data used in this chapter combines information from a range of different sources – some of which is publicly available, some of which has rarely been made available for research before.

In the UK, applications to full-time undergraduate courses are channelled through a centralised clearing house – the Universities and Colleges Admissions Service (or UCAS). The starting point for the dataset used in this chapter was individualised UCAS data (holding detailed information on every single applicant and his/her choices of universities, as well as universities' admission decisions) for the years 2002 to 2009. This data was collapsed at the institutional level to build a time series[49] of UK-domiciled applications[50], successful applications, average entry score of applicants, and average entry score of accepted applicants. In total this creates a dataset with 1,105 institution/year combinations with non-missing information.

The number of applications from UK-domiciled students could be broken down by a range of socio-demographic characteristics held on the UCAS data, namely: gender, age, ethnicity, socio-economic class, type of school attended, and academic ability of applicants (as measured by their tariff score). Using the same dataset, a separate time series at institutional level was created with the number of applications from international students (broken down by whether they come from the EU or other overseas countries[51]).

For international students, it was also possible to build a time series of fees charged by institutions[52] using Mike Reddin's annual survey[53].

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[49] One difficulty encountered in building a time series is institutional changes – mergers in particular. The general approach taken was to treat institutions as separate before they merged, and then as one (separate) institution afterwards.

[50] Note that each applicant in the UCAS system is entitled to a certain number of choices/applications – six prior to 2008/09, and five from that year onwards. The analysis in this paper will be at the level of the choice/application, and not the applicant level.

[51] This distinction is important because EU students in the UK are eligible to pay the same fees as domestic students. Other overseas students are subject to much higher fee levels.

[52] For the time period studied, university fees for domestic and EU students were virtually all the same. Only a handful of institutions briefly charged slightly lower fees when the fees cap was raised in 2006/07 to £3,000.

[53] The data is available from the website www.publicgoods.co.uk. Sometimes a range of fees was provided, and a judgment needed to be made to choose either the lower or higher fee stated to make sure that the time series for each institution was as consistent as possible.

Finally, using a range of printed and online material, the dataset was completed with information on universities' rankings from the following league tables: the Times Good University Guide, the Guardian University Guide, the Times Higher Education (THES) World University Rankings, and the Academic Ranking of World Universities (ARWU, or "Shanghai Ranking"). For the period 2002-2009 (for which UCAS data was available), the following table summarises which rankings information is included in the dataset, and the number of institutions for which information is available in any particular year. As the table shows, the number of institutions with rankings information varies across league table as well as over time[54]. As a result, the number of observations used in the regression analysis will fluctuate depending on the outcome/ranking combination looked at.

Table 4-1: Availability of Rankings Information by Year (Number of Institutions)

	2002	2003	2004	2005	2006	2007	2008	2009	TOTAL
Times	95	99	100	99	100	109	109	112	823
Guardian			116	118	121	120	119	116	710
THES*			30	24	28	31	29	29	171
ARWU*		39	38	38	41	39	39	37	271

* UK institutions only.

Table 4-2 below summarises some of the key outcome variables that will be used in this chapter. On average, institutions receive about 12,500 applications from UK-domiciled students and around 2,000 from international applicants. 72% of UK-domiciled applications are accepted, compared to 66% of overseas applications. The average tariff score is 231 points for applicants and 252 for accepted applicants. Over the period studied, overseas students were charged an average of £8,155 for classroom-based courses and £9,284 for laboratory-based courses (in nominal terms).

A priori, it is not obvious what effect (if any) a change in rank should have on the number of applications universities receive. Institutions that rise in the rankings (i.e. become better ranked)[55] may attract more applications because candidates seek out the best universities. Equally possible, however, is that applicants shun those universities because they perceive their chances of being admitted to them reduced, in which case we would observe a fall in the number of applications received. Most of the evidence

[54] Although rare, there are some institutions which refuse to participate in the rankings.
[55] Throughout this paper, the highest rank an institution can attain is 1. An institution will be considered to "rise" in the rankings if it moves, for example, from position 7 to 3. Vice versa, a move from rank 3 to 7 will be described as a "drop" in the league tables. All results presented in section 4.5 will be based on a one place "drop" in the rankings (i.e. an increase in the actual ranking value).

for the US summarised in section 4.2 suggests that more highly ranked institutions do attract more applications. Evidence for the UK is more mixed but also suggests that, if there is any effect, it tends to be positive.

Table 4-2: Summary of Key Outcome Variables

	Mean	Std. Dev.	Min	Max
UK-Domiciled Applicants				
# of Applications by Institution	12,537	9,770	148	51,636
Male	*5,639*	*4,558*	*42*	*24,044*
Female	*6,898*	*5,334*	*83*	*28,443*
*White**	*9,947*	*8,164*	*106*	*40,874*
Black	*634*	*962*	*0*	*6,868*
Asian	*1,229*	*1,525*	*0*	*7,334*
Mixed Ethnicity	*332*	*318*	*0*	*1,705*
Young§	*10,773*	*8,749*	*130*	*46,039*
Mature	*1,764*	*1,472*	*18*	*8,526*
*Higher Socio-Economic Class**	*6,999*	*6,091*	*113*	*33,025*
Lower Socio-Economic Class	*3,226*	*2,438*	*13*	*12,861*
State School†	*7,176*	*6,015*	*37*	*32,140*
Independent School	*1,310*	*2,046*	*0*	*11,156*
Proportion of Applications Accepted	72%	18%	14%	100%
Average Tariff Score of Applicants	231	83	58	476
Average Tariff Score of Accepted Applicants	252	95	69	516
International Applicants				
# of EU Applications by Institution	736	767	2	6,107
Proportion of EU Applications Accepted	66%	20%	3%	100%
# of Other Overseas Applications by Institution	1,220	1,522	1	9,604
Proportion of Other Overseas Applications Accepted	66%	17%	6%	100%
Average Fee for Classroom-Based Courses (£)	8,155	1,542	4,325	18,000
Average Fee for Laboratory-Based Courses (£)	9,284	2,167	4,325	20,400

* The "other ethnicity" category has been left out of the analysis.
§ Following standard practice, young applicants are those aged 20 and below.
° Higher socio-economic classes cover classes 1 to 3: higher managerial/professional occupations, lower managerial/professional occupations and intermediate occupations. Lower socio-economic classes span groups 4 to 7: small employers and own account workers, lower supervisory and technical occupations, semi-routine occupations, and routine occupations. Those with unknown socio-economic class are not included in the analysis.
† The focus is on state and independent schools. Some other school types (e.g. further education colleges) have been left out of the analysis).

The effect of rank changes on applications may vary according to applicant and institution characteristics. Higher attaining candidates, for example, may be more likely to seek out better ranked institutions, which would lead to an increase in the average entry qualifications of applicants to institutions that move up the rankings. Section 4.2 shows that, in the US, this is indeed the case. There is also some evidence from the US that changes in rankings might be associated with changes in the socio-demographic make-up of universities (Meredith, 2004).

In addition, if more highly ranked institutions receive more applications, we would expect their admission rate (i.e. the proportion applications which are successful) to fall – particularly if institutions operate under capacity constraints. Similarly, we would expect those institutions to be more selective in their intake and accept the most qualified candidates only. Once again, this would lead to an increase in the average entry qualifications of accepted applicants.

Finally, if moving up in the rankings means that institutions receive more applications from international students[56], then simple economic theory would predict an increase in the price that those universities are able to ask for their courses. On the other hand, it is possible that universities would be averse to lowering their fees in reaction to a drop in the rankings because this might send the wrong signals to potential applicants about the quality of education on offer at that institution. The limited evidence from the US presented in section 4.2 corroborates this: institutions adjust the financial aid packages they offer, but not the 'sticker price' of courses.

[56] In the UK, the number of full-time undergraduate places available to UK-domiciled students is, to a large extent, fixed exogenously by the funding councils. International students do not, therefore, displace home students. So the proportion of international students accepted should be independent from the proportion of UK-domiciled students accepted.

4.4. Methodology

The effect of movements in league table positions on the outcomes outlined in section 4.3 will be analysed using the following dynamic panel model estimated by Ordinary Least Squares:

$$Outcome_{x\,t+1} = \beta_0 + \beta_1\, RANK_{x\,t} + \beta_2\, RANK_{x\,t-1} + \sum \upsilon_x\, U_x + \sum \psi_t\, Y_t \qquad (4i)$$

Where the outcome for institution x in year $t+1$ will be regressed on a constant (β_0), the institution's current and previous rank ($RANK_{xt}$ and $RANK_{xt-1}$), and institution (U_x) and year (Y_t) fixed effects. In all regressions, standard errors will be clustered at the institutional level.

It is assumed that applicants to university use the most recently published league tables. Most guides are published in late summer in time for the applications process (which starts in autumn) for enrolment in the following academic year. Similarly, for international student fees, it will be assumed that fees in any particular year are set based on the institution's ranking in the previous year[57].

The inclusion of institution fixed effects means that the impact of league table changes will be identified using within-institution variation and that any time-invariant, unobserved heterogeneity at the university level will be eliminated. The inclusion of year fixed effects is needed to absorb any time trends common to all universities including, for example, the 2008/09 UCAS policy to reduce the number of choices each candidate can express on their application form from six to five, as well as the increase of tuition fees in England in 2006/07. Finally, the inclusion of the institution's previous rank (which is generally published alongside the institution's current rank) will control for the extent and direction of a change in ranking.

For the above model to be able to identify the effect of rank changes on the outcomes of interest there needs to be sufficient annual change in institutions' rankings. As shown in Table 4-3 below, this is indeed the case: nearly all institutions change rank each year and, in the case of some league tables, over two thirds of institutions move five or more places a year. The graphs and correlations matrices in Annex 4A show year-on-year

[57] Annex 4B provides an example of how the rankings would be matched up to the outcome variables in the analysis.

changes for each of the rankings, and confirm the considerable annual movement in university league tables.

Table 4-3: Summary of Yearly Changes in Rank

	Times	Guardian	THES	ARWU[58]
% of Institutions Changing Rank	91.2%	95.4%	96.2%	71.4%
% of Institutions Changing Rank by 5+ Places	39.1%	68.2%	69.9%	21.0%
Average Yearly Change in Rank	5.1	12.0	16.6	13.1

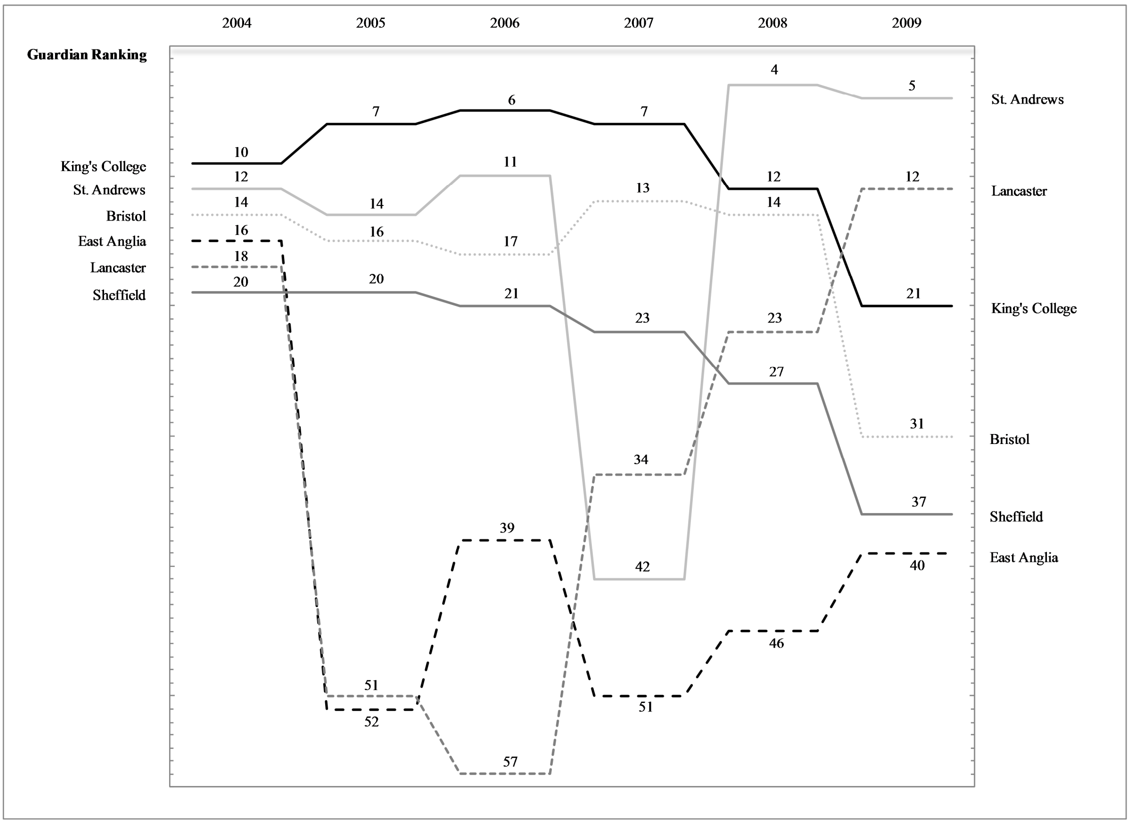
As a further illustration of the volatility in rankings, Figure 4-1 shows shifts in ranking over time for universities that were ranked 10, 12, 14, 16, 18 and 20 in 2004 by the Guardian. As this graph shows, there is considerable movement in universities' league table positions over time and much of it appears random (e.g. the University of St. Andrews' ranking in 2007).

Some rankings display more change over time than others. Often this is due to changes in the methodology used for constructing the rankings. Annex 4C provides more detail on the annual changes in the methodology for constructing the Guardian rankings, and this shows that there are frequent changes in variables and weights used. According to Roberts and Thompson (2007), "those constructing league tables have a vested interest in them being dynamic – annual change within rankings is good for business and for publicity". Whatever the reason, these methodological adjustments generate apparently random changes in rankings from one year to the next, which are likely to be independent from changes in the actual quality of the university itself. This creates ideal conditions for estimating the effect of rank changes on institution and applicant behaviour, as rank changes appear to a large extent exogenous[59].

[58] One issue with the ARWU rankings is that detailed information on an institution's position is not available for every university included in the league table. Although the individual ranking is known for institutions in the top 100, universities outside the top 100 are ranked in groups: 101-150, 151-200, 201-300, 301-400 and 401-500, and so changes in ranking for institutions outside the top 100 are not captured unless they actually change group. Throughout this chapter, the ARWU rankings are treated as a continuous variable (with institutions outside the top 100 given a rank of 101, 151, 201, 301 or 401). The robustness of the results to this assumption has been tested by re-running the analysis on a reduced sample of institutions appearing in the top 100 only. As for the results in the main body of the chapter, the ARWU rankings appear to have no or very little impact on applicant behaviour – although this finding is likely attributable to the small number of observations (39) available.

[59] Unless, of course, prospective students are aware of and heed such methodological changes, in which case they could dismiss the information value of league tables (or, at least, sudden and large annual changes).

Figure 4-1: Changes in Rank of Universities Ranked 10, 12, 14, 16, 18 and 20 in 2004 by the Guardian



Annex 4C also summarises changes in the methodology for deriving the Times league table: although there are some changes here too, they are less frequent and less dramatic than in the case of the Guardian ranking. This is confirmed in the correlation matrices presented in Annex 4A, where year-on-year correlations for the Times rankings are much stronger than for the Guardian. It was not possible to document similar changes in methodology for either the THES or ARWU rankings.

One final limitation of the fixed effects model outlined above is that it relies on the crucial assumption that time trends are common across all universities. Should there be heterogeneity in unobserved trends, however, then the estimates of the effect of rankings on the outcomes of interest would be biased. In order to test the sensitivity of the results to this assumption, additional regressions were run where the year fixed effects in equation (4i) above were replaced by a linear time trend T and interacted with each of the institutional dummies:

$$Outcome_{x\,t+1} = \beta_0 + \beta_1 RANK_{x\,t} + \beta_2 RANK_{x\,t-1} + \beta_3 T + \sum \upsilon_x U_x + \sum \upsilon_t U_t T \qquad (4ii)$$

The findings presented in section 4.5 below are robust to the inclusion of such institution-specific linear time trends – suggesting that unobserved time-varying heterogeneity at the university level may not be a major concern[60].

4.5. Results

Table 4-4 shows the estimated effect of a change in rankings on the number of UK-domiciled applications, the proportion of applications which are successful, the average tariff score of applicants, and the average tariff score of accepted applicants. Each time, the effect shown is for a one place drop in the rankings (i.e. the institution's rank worsens), and the table contains the estimated coefficient, the standard error, the number of observations, as well as the mean of the outcome variable for that particular ranking/outcome combination.

The first column investigates the effect on the number of applications received by an institution. Although the effect of the Times ranking is not statistically significant, it is similar in magnitude to that of the Guardian ranking which suggests that a ten place drop in the rankings leads to about 100 fewer applications. Given that institutions included in the Guardian ranking over the period 2004-2009 received on average 15,031 applications per year, this equates to a 0.66% reduction[61]. This effect is small and may explain why, in the second column, we find no evidence of an impact on the proportion of applications that are successful.

Columns (iii) and (iv) suggest that institutions that drop down the rankings receive applications from less well-qualified applicants overall which, combined with the fall in applications observed in column (i), also leads to a decline in the average tariff score of accepted applicants at those institutions. Again, however, the effect is modest: a ten place fall in the rankings leads to a decline in tariff score of applicants and accepted applicants of between 0.5% and 0.9%[62].

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[60] The only exception being that the inclusion of institution-specific time trends turns the effect of a drop in the ARWU rankings on international student fees positive (i.e. fees increase when an institution falls down the ARWU rankings) – which appears counterintuitive and is not corroborated by any of the other results. All results from the models with institution-specific time trends can be found in Annex 4D.

[61] Percentage changes here and elsewhere in the chapter are calculated on the basis of the mean value for the institutions with non-missing rankings information.

[62] These models assume that league tables are mutually exclusive and that students only use one of the rankings in deciding which universities to apply to. In practice, however, it is possible (and likely) that candidates consult a range of rankings and make a decision based on some weighted average of universities' positions across the various league tables. To test for this, a new variable was created which measures an institution's average ranking across both the Times and Guardian guides, and the main

Table 4-4: Impact of a Drop in Rankings on Applications, Proportion of Applications Accepted and Average Tariff Score of (Accepted) Applicants – UK-Domiciled Students

		(i)	(ii)	(iii)	(iv)
		Number of Applications	% of Applications Accepted	Average Tariff Score of Applicants	Average Tariff Score of Accepted Applicants
Times	B	-12.03	0.000177	-0.217	-0.248
	s.e.	(11.35)	(0.000255)	(0.0874)**	(0.0979)**
	N	671	671	671	671
	$\bar{X}$	16251	0.73	247	270
Guardian	B	-9.923	0.000150	-0.116	-0.148
	s.e.	(4.820)**	(0.000117)	(0.0315)***	(0.0344)***
	N	565	565	565	565
	$\bar{X}$	15031	0.74	237	259
THES	B	0.416	0.000117	-0.0284	-0.0912
	s.e.	(8.455)	(0.000273)	(0.0839)	(0.0945)
	N	123	123	123	123
	$\bar{X}$	21738	0.58	350	393
ARWU	B	-7.855	0.000128	-0.0379	-0.0395
	s.e.	(6.076)	(0.000122)	(0.0374)	(0.0443)
	N	170	170	170	170
	$\bar{X}$	19837	0.62	334	372

* 0.10 ** 0.05 *** 0.01

Table 4-5 below explores whether the effect is different for more prestigious universities. As a proxy for prestige, we look at institutions which belong to the Russell Group – a self-formed grouping of 20 research-intensive institutions in the UK[63] generally regarded as being highly selective. The results presented in the first column of Table 4-5 show a considerably larger effect of a fall in the rankings on the number of applications received by Russell Group institutions: a ten place drop in the rankings leads to a fall of between 2.7% (the Guardian) and 6.2% (the Times)[64]. This echoes findings from the US, where the impact of league tables was found to be strongest for highly ranked and private institutions.

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analysis from Table 4-4 was re-run. The results can be found in Annex 4E and are very similar to those obtained here. Annex 4E also presents results of a regression where both the Guardian and Times ranking were entered simultaneously. Again, the results are similar to those obtained in Table 4-4.

[63] These are the universities of: Birmingham, Bristol, Cambridge, Cardiff, Edinburgh, Glasgow, Leeds, Liverpool, Manchester, Newcastle, Nottingham, Oxford, Sheffield, Southampton, as well as Imperial College London, King's College London, the London School of Economics and Political Science, Queen's University Belfast and University College London. For more information, see: http://www.russellgroup.ac.uk/

[64] The average annual change in rank for Russell Group institutions in the Times ranking is 2.7. For the Guardian ranking it is 4.7.

Table 4-5: Impact of a Drop in Rankings on Applications, Proportion of Applications Accepted and Average Tariff Score of (Accepted) Applicants – UK-Domiciled Students, Russell Group Institutions

		(i)	(ii)	(iii)	(iv)
		Number of Applications	% of Applications Accepted	Average Tariff Score of Applicants	Average Tariff Score of Accepted Applicants
Times	β	-156.9	0.00187	-0.707	-0.590
	s.e.	(58.59)**	(0.00126)	(0.362)*	(0.330)*
	n	126	126	126	126
	$\bar{X}$	25458	0.55	355	400
Guardian	β	-70.29	0.000411	0.178	0.125
	s.e.	(28.00)**	(0.000612)	(0.206)	(0.248)
	n	90	90	90	90
	$\bar{X}$	25764	0.54	355	401
THES	β	1.122	0.000148	0.0182	-0.0797
	s.e.	(13.56)	(0.000219)	(0.0711)	(0.0665)
	n	81	81	81	81
	$\bar{X}$	26133	0.53	359	407
ARWU	β	-0.951	0.000153	-0.000679	-0.0353
	s.e.	(6.519)	(0.000192)	(0.0444)	(0.0588)
	n	89	89	89	89
	$\bar{X}$	25531	0.54	355	401

* 0.10 ** 0.05 *** 0.01

The results further suggest that a ten place drop in the Times rankings leads to a 2.0% fall in the average tariff score of applicants and a 1.5% fall in the average tariff score of accepted applicants at Russell Group institutions. As before, the two international rankings (THES and ARWU) appear to have no effect on the application decisions of home-domiciled students.

Table 4-6, Table 4-7 and Table 4-8 explore heterogeneity in the response to rank changes by applicant characteristics. In particular, the tables explore whether the number of applications received from certain groups of students are more sensitive to a change in rankings than others. The results suggest that the candidates who react most to a change in rankings tend to be male, young, Asian, high-attaining, from higher socio-economic classes, and from independent schools – a finding consistent with the evidence presented in section 4.2 on the types of students most likely to consult university league tables, as well as with evidence from the US.

The tables also suggest that the numbers of Black and mature applications increase rather than decrease when an institution falls in the rankings – a finding which is confirmed by a separate series of regressions where the outcome variable is replaced by the proportion of applications with a certain characteristic: institutions that experience a drop in the rankings see an increase in the proportion of applications received which are Black and mature (see Annex 4F). This is a finding similar to that of Meredith (2004) who writes that "a one-rank drop in the USNWR is shown to decrease the number of Asians in an incoming class by 0.11%, the number of Hispanics by 0.09%."

Table 4-6: Impact of a Drop in Rankings on the Number of Applications by Gender and Ethnicity – UK-Domiciled Students

		Gender		Ethnicity			
		Male	Female	White	Black	Asian	Mixed
Times	β	-11.67	-0.361	-8.823	3.732	-5.011	0.155
	s.e.	(5.252)**	(6.632)	(9.882)	(2.681)	(1.350)***	(0.694)
	n	671	671	671	671	671	671
	$\bar{X}$	7424	8827	12838	828	1652	432
Guardian	β	-6.075	-3.848	-9.805	2.736	-1.641	0.265
	s.e.	(2.210)***	(2.898)	(4.111)**	(0.991)***	(0.622)***	(0.200)
	n	565	565	565	565	565	565
	$\bar{X}$	6741	8290	11872	829	1490	426
THES	β	1.654	-1.239	-0.973	-0.147	1.501	-0.299
	s.e.	(3.814)	(5.133)	(6.802)	(0.654)	(1.095)	(0.414)
	n	123	123	123	123	123	123
	$\bar{X}$	10282	11456	17535	743	2200	663
ARWU	β	-2.694	-5.161	-6.836	-0.151	-0.185	-0.122
	s.e.	(2.749)	(3.635)	(4.927)	(0.628)	(0.753)	(0.261)
	n	170	170	170	170	170	170
	$\bar{X}$	9354	10484	16193	674	1870	572

* 0.10 ** 0.05 *** 0.01

Table 4-7: Impact of a Drop in Rankings on the Number of Applications by Age and Socio-Economic Class – UK-Domiciled Students

		Age		SEC	
		Young	Mature	High	Low
Times	β	-16.58	4.548	-11.60	-0.804
	s.e.	(9.844)*	(3.429)	(5.965)*	(3.206)
	n	671	671	671	671
	$\bar{X}$	14016	2236	9143	4131
Guardian	β	-12.81	2.891	-6.999	-2.422
	s.e.	(4.307)***	(1.535)*	(2.592)***	(1.455)*
	n	565	565	565	565
	$\bar{X}$	12862	2168	8224	3848
THES	β	1.322	-0.907	1.059	0.300
	s.e.	(7.804)	(1.564)	(5.635)	(1.930)
	n	123	123	123	123
	$\bar{X}$	19613	2125	14016	4254
ARWU	β	-7.428	-0.427	-5.654	-0.700
	s.e.	(5.775)	(1.103)	(4.083)	(1.704)
	n	170	170	170	170
	$\bar{X}$	17834	2003	12608	4037

* 0.10 ** 0.05 *** 0.01

Table 4-8: Impact of a Drop in Rankings on the Number of Applications by School Type and Prior Attainment – UK-Domiciled Students

		School Type		Prior Attainment			
		State	Independent	Top	Top Middle	Bottom Middle	Bottom
Times	β	-13.81	-6.261	-14.72	-3.098	9.458	-3.669
	s.e.	(9.355)	(2.084)***	(3.969)***	(4.369)	(4.797)*	(4.590)
	n	462	462	671	671	671	671
	$\bar{X}$	9531	1826	4215	4165	3964	3908
Guardian	β	-10.39	-1.813	-3.006	-3.121	-4.047	0.251
	s.e.	(4.268)**	(0.608)***	(1.191)**	(1.588)*	(2.058)*	(2.331)
	n	338	338	565	565	565	565
	$\bar{X}$	8712	1555	3762	3823	3709	3737
THES	β	2.674	3.339	1.787	0.521	-1.508	-0.384
	s.e.	(4.039)	(2.162)	(4.752)	(2.420)	(2.883)	(2.226)
	n	68	68	123	123	123	123
	$\bar{X}$	13451	4405	10557	5776	2551	2855
ARWU	β	-0.573	-1.852	-4.724	-4.110	-0.0871	1.066
	s.e.	(4.213)	(1.726)	(3.241)	(2.421)*	(1.877)	(2.048)
	n	101	101	170	170	170	170
	$\bar{X}$	12334	3647	8982	5485	2648	2722

* 0.10 ** 0.05 *** 0.01

Further investigation suggests that these findings may be restricted to certain institutions only: the Black finding, for instance, appears to be concentrated in London institutions and those that are consistently in the bottom tercile of the rankings[65]. With the fixed effects regression model used, the concern would be that there are underlying trends at those institutions which are correlated both with changes in ranking and with changes in the number (or proportion) of Black and mature applications. The existence of such unobserved trends would cause a spurious relationship between changes in rankings and changes in applications from certain groups. However, the findings about Black and mature applications are robust to the inclusion of institution-specific time trends, which should help in controlling for such time-varying unobserved heterogeneity. Although not proving the existence of a causal relationship between changes in rankings and the number of Black/mature applications, this suggests that the results should not be dismissed as a statistical artefact and that further research into the issue is warranted[66].

Finally, Table 4-9 explores the effect of a change in rankings on the number of applications received from EU and other overseas candidates, the proportion of these that are successful, and the fees charged by institutions to international students. Two fees columns are presented – the first is for fees charged for classroom-based courses, the second is for fees charged for laboratory-based courses.

As was the case for domestic candidates, a fall in the Guardian and Times rankings is associated with a reduction in the number of EU and other overseas applications received by institutions. Again, the magnitude of a ten place drop in the rankings is relatively modest and ranges between 0.26% and 0.29% for EU applications, and between 0.19% and 0.47% for other overseas applications. The effect on the proportion of EU applications accepted is ambiguous, and no statistically significant effect could be detected on the proportion of other overseas applications accepted. Although higher ranked institutions may charge higher fees to international students, the results in Table 4-9 suggest that there is no evidence that institutions adjust their fees in response to an annual change in rankings. This would be consistent with evidence from the US, where

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[65] For each institution the annual Times and Guardian rankings were standardised and averaged. These were used to obtain an average ranking for the institution over the period 2002-2009. Using this average ranking over the period, the sample was split into terciles.

[66] In the case of Black and mature applications, the simple models used in this chapter result in a within-institution R^2 of around 0.40. Although relatively large considering the parsimonious models used, it also suggests that a large proportion of the annual variation in applications to institutions is driven by factors other than rankings.

institutions were found not to change the sticker price of courses following a change in rankings (Monks and Ehrenberg, 1999).

Table 4-9: Impact of a Drop in Rankings on Applications, the Proportion of Applications Accepted, and Fees Charged – International Students

		(i)	(ii)	(iii)	(iv)	(v)	(vi)
		Number of EU Applications	% of EU Applications Accepted	Number of Other Overseas Applications	% of Other Overseas Applications Accepted	Fees Classroom-Based Courses	Fees Laboratory-Based Courses
Times	β	-2.770	0.000448	-7.967	0.000422	-3.601	-4.810
	s.e.	(1.599)*	(0.000487)	(2.006)***	(0.000416)	(2.481)	(3.919)
	n	780	692	671	671	799	799
	$\overline{X}$	967	0.73	1665	0.67	8573	9999
Guardian	β	-2.440	0.0000820	-2.780	0.0000963	-0.105	-1.479
	s.e.	(0.566)***	(0.000199)	(0.868)***	(0.000284)	(1.387)	(1.809)
	n	683	683	565	565	684	684
	$\overline{X}$	952	0.74	1483	0.67	8690	10015
THES	β	-1.364	-0.000517	2.655	-0.0000973	-3.603	-4.281
	s.e.	(1.233)	(0.000271)*	(3.270)	(0.000311)	(2.240)	(2.960)
	n	160	160	123	123	130	130
	$\overline{X}$	1797	0.58	3472	0.56	9886	12265
ARWU	β	0.0910	0.000284	-0.0698	-0.0000727	1.723	2.228
	s.e.	(1.296)	(0.000133)**	(1.381)	(0.000338)	(2.040)	(2.908)
	n	214	214	170	170	220	220
	$\overline{X}$	1571	0.62	2938	0.59	9800	12159

* 0.10 ** 0.05 *** 0.01

A final observation concerns the slightly surprising result that the international rankings (THES, but particularly ARWU) appear to have no effect on international applicants. Although it is possible that international students only use rankings information once they have already chosen the country they wish to study in (in which case they might as well use domestic rankings because these cover a wider range of institutions), it is more likely that the lack of significant results is due to the smaller sample sizes available for the international rankings. Future research should therefore seek to test this result by building longer time series.

4.6. Conclusion

This chapter adds to the limited evidence on the effects of university rankings on institutions and applicants in the UK. The results suggest that rankings do matter in the UK. Overall, their effect is modest, although the impact on some types of applicants and institutions is stronger.

Comparing these results with previous findings for the US is not straightforward, as the US papers tend to focus on particular institutions (mainly top/elite institutions), or look at changes from one quartile of the rankings to another. In addition, effects are frequently expressed in percentage point changes, and so the actual importance of the change (in percentage terms) remains unclear. Nevertheless, the table in Annex 4G attempts to summarise some of the key findings from the US literature and suggests that the results found in this chapter are certainly not out of line with those found in the US.

It is significant to find that university rankings have an impact on applicant and institution behaviour. However, judging by the modesty of the effects uncovered, rankings are clearly not the only driver of applicant choice. As Clarke (2007) notes: "some mix of the following factors likely influences students' applications and enrolment decisions: perceived academic quality and reputation of the institution in general and academic program in particular, entry requirements, location, tuition costs, financial aid availability, infrastructure, employment prospects for graduates, social life, advice of significant persons, and commercially-produced materials such as guidebooks and ranking publications." Soo (2011) (who concludes that the Sunday Times University Guide has no statistically significant impact on applications in the UK) does find some evidence of persistence in perceptions and applications, suggesting that general reputational factors are important.

This chapter looked at the impact of rankings in the UK over the period 2002-2009, during which the maximum fee charged by institutions was kept artificially low. In England, tuition fees are set to rise to a maximum of £9,000 from September 2012 onwards. It may be that, with the increasing marketisation of higher education in the UK, league tables will play an increasingly important role in applicants' decisions in years to come[67]. In this sense, this chapter may be regarded as a baseline to compare future studies with.

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[67] Although the fee cap was also raised in 2006/07, it was part of a comprehensive package of reforms to student finance (including the introduction of student loans to cover the cost of fees and the deferral of repayments until after graduation), which meant that the net upfront cost of going to university was actually reduced (Dearden, Fitzsimons and Wyness, 2010). As a result, it is unsurprising that no clear effect of raising the fee cap on the relationship between university ranking and applications to university could be detected (see Annex 4H for further detail).

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Annex 2A: Chapter 2 Literature Review

To the best of my knowledge, no economic studies have looked specifically at the effect of curriculum structure and offer on subsequent subject choice and attainment. However, a wider economic literature exists which addresses the issue of subject choice in school and higher education. This literature covers either: (i) the socio-demographic characteristics which are associated with the study of particular subjects; or (ii) the role of rates of return in subject choice. The former is predominantly descriptive in nature, whereas the latter attempts to uncover the intrinsic motivations behind pupils' choice of subject.

Socio-Demographic Characteristics Associated with Subject Choice

Starting with the socio-demographic characteristics associated with subject choice in higher education, Chowdry et al. (2008) use a dataset similar to the one used in this chapter, and find that a student's level of deprivation is not statistically associated with whether or not he/she chooses to study a STEM subject and that, by and large, more deprived students are more likely to study subjects with clear economic returns in the labour market (including Law). They also find that ethnic minority groups are significantly less likely to enrol in a STEM subject than their White counterparts, but more likely to enrol in high-wage-return degrees, including Law. This appears to chime with earlier analysis by Connor et al. (2004) who find a considerably higher concentration of minority ethnic students in Medicine/Dentistry, Computer Science and Law. By contrast, ethnic minority students are not well represented in the Physical Sciences, Languages, Art and Design, Humanities, Education, Veterinary Science and Agriculture.

With regards to socio-economic class, Bratti (2006) also concludes that it has no effect on students' undergraduate degree subject choice in the UK. Van de Werfhorst et al. (2003), however, find that children of the professional class were relatively more likely to choose Medicine and Law at university – although the authors themselves point out that this might be due to the specific characteristics of the cohort studied: at the time of the study only a very small minority of the working class entered higher education, and this could be considered as a very particular and selected group (e.g. in terms of academic ability). Van de Werfhorst et al. (2003) do find (consistent with the aforementioned studies) that ability/prior attainment plays a crucial role, as well young people's "comparative" advantage in certain subjects (i.e. young people choose to study subjects that they are relatively good at). Finally, the authors find a strong association between gender and subject choice.

The above studies are the only ones I am aware of which look at subject choice in higher education in the UK. At secondary school level, such studies are less common and are often more closely affiliated with the education than with the economics literature (see, for instance, Ashworth and Evans, 2001; Davies et al., 2004; Bachan and Barrow, 2006; and Vidal Rodeiro, 2007). Mostly, these studies find effects of socio-demographic variables and prior attainment similar to the ones discussed above in the context of higher education, although there are some interesting additional findings. For example, both Davies et al. (2004) and Ashworth and Evans (2001) find that the characteristics of the cohort of the students at the school (peer effects) are strongly associated with subject choice (e.g. proportion of students eligible for Free School Meals, the proportion of female students studying a particular subject, and the overall ability of fellow students).

Turning to studies from outside the UK, Smyth and Hannan (2006) look at how school factors (such as subject provision (including time-tabling), the timing of subject choice, and ability grouping) influence the take-up of Biology, Physics and Chemistry at the upper secondary level in the Republic of Ireland. Unfortunately, the authors only look at the effect on immediate subject choice (i.e. whether the availability of one subject in the school has an effect on whether pupils take up other subjects or not), and not on later outcomes (which is the focus of Chapter 2 in this thesis). They find that students are more likely to take science subjects if they find them interesting and useful, and if they do well in science. The authors also conclude that the take-up of science subjects reflects a school's decision about whether to provide a subject or not, along with school organisation and process at both lower and upper secondary levels.

The Role of Rates of Return in Subject Choice

This brings us onto the studies investigating the reasons behind subject choice. As mentioned above, these studies have tended to focus almost exclusively on the role of (expected) earnings on subject choice, as well as on people's attitudes towards risk. Moreover, nearly all of these studies have been carried out outside the UK.

Using Canadian data, Montmarquette et al. (2001) find that expected earnings influence subject choice and that the effect is twice as large for males as for females. The effect is also larger for the non-white population than for the white group, but does not vary by socio-economic class.

Rochat and Demeulemeester (2001) use data for Belgium and show that young people pay attention not only to the expected economic benefits, but also to the length of studies and the probability of succeeding in a chosen orientation. They find that the richest students do not appear to be sensitive to either the expected chances of success or the economic benefits linked with their orientation choice. Replicating this study using Italian data, Buonanno and Pozzoli (2007) also find that students take into account the a priori probability of success when choosing a college subject, and that students coming from a lower socio-economic background display more risk aversion. They believe that their findings can help explain an apparent paradox in the labour market where quantitative subjects are highly rewarded, yet the supply of suitable graduates does not appear to increase in response to those signals.

Annex 2B: Chapter 2 Variable Description

Table 2B-1: Explanatory Variables: Individual Socio-Demographics

Variable	Description	Unique Values	Mean	Min	Max
female	Dummy for whether individual is female.	2	0,494	0	1
fsm_reg	Dummy for whether individual was on Free School Meals at age 15. Missing values have been set to 0.	2	0,138	0	1
fsm_missing	Dummy for whether FSM information is missing.	2	0,001	0	1
quartile1	Dummy for whether individual lived in 25% most deprived areas. Omitted category is for individuals living in 25% least deprived areas.	2	0,248	0	1
quartile2	Dummy for whether individual lived in 25% second most deprived areas. Omitted category is for individuals living in 25% least deprived areas.	2	0,248	0	1
quartile3	Dummy for whether individual lived in 25% second least deprived areas. Omitted category is for individuals living in 25% least deprived areas.	2	0,248	0	1
Quartilem	Dummy for whether area deprivation information was missing.	2	0,009	0	1
eth_w_oth	Dummy for whether individual belonged to White Other ethnic group. Omitted category is White UK.	2	0,022	0	1
eth_a_ind	Dummy for whether individual belonged to Asian Indian ethnic group. Omitted category is White UK.	2	0,025	0	1
eth_a_pak	Dummy for whether individual belonged to Asian Pakistani ethnic group. Omitted category is White UK.	2	0,024	0	1
eth_a_ban	Dummy for whether individual belonged to Asian Bangladeshi ethnic group. Omitted category is White UK.	2	0,009	0	1
eth_a_oth	Dummy for whether individual belonged to Asian Other ethnic group. Omitted category is White UK.	2	0,003	0	1
eth_b_car	Dummy for whether individual belonged to Black Caribbean ethnic group. Omitted category is White UK.	2	0,014	0	1
eth_b_afr	Dummy for whether individual belonged to Black African ethnic group. Omitted category is White UK.	2	0,013	0	1
eth_b_oth	Dummy for whether individual belonged to Black Other ethnic group. Omitted category is White UK.	2	0,006	0	1
eth_chi	Dummy for whether individual belonged to Chinese ethnic group. Omitted category is White UK.	2	0,004	0	1
eth_mix	Dummy for whether individual belonged to Mixed ethnic group. Omitted category is White UK.	2	0,009	0	1
eth_oth	Dummy for whether individual belonged to Other ethnic group. Omitted category is White UK.	2	0,057	0	1
eth_w_oth _86	Dummy for whether individual belonged to Other ethnic group AND to the 1986 cohort. Omitted category is White UK.	2	0,009	0	1
eth_a_ind _86	Dummy for whether individual belonged to Other ethnic group AND to the 1986 cohort. Omitted category is White UK.	2	0,012	0	1

Variable	Description	Unique Values	Mean	Min	Max
female	Dummy for whether individual is female.	2	0,494	0	1
eth_a_pak _86	Dummy for whether individual belonged to Other ethnic group AND to the 1986 cohort. Omitted category is White UK.	2	0,012	0	1
eth_a_ban _86	Dummy for whether individual belonged to Other ethnic group AND to the 1986 cohort. Omitted category is White UK.	2	0,005	0	1
eth_a_oth _86	Dummy for whether individual belonged to Other ethnic group AND to the 1986 cohort. Omitted category is White UK.	2	0,003	0	1
eth_b_car _86	Dummy for whether individual belonged to Other ethnic group AND to the 1986 cohort. Omitted category is White UK.	2	0,007	0	1
eth_b_afr _86	Dummy for whether individual belonged to Other ethnic group AND to the 1986 cohort. Omitted category is White UK.	2	0,007	0	1
eth_b_oth _86	Dummy for whether individual belonged to Other ethnic group AND to the 1986 cohort. Omitted category is White UK.	2	0,002	0	1
eth_chi _86	Dummy for whether individual belonged to Other ethnic group AND to the 1986 cohort. Omitted category is White UK.	2	0,002	0	1
eth_mix _86	Dummy for whether individual belonged to Other ethnic group AND to the 1986 cohort. Omitted category is White UK.	2	0,009	0	1
eth_oth _86	Dummy for whether individual belonged to Other ethnic group AND to the 1986 cohort. Omitted category is White UK.	2	0,032	0	1
Sen	Dummy for whether individual had Special Educational Needs	2	0,160	0	1
sen_86	Dummy for whether individual had Special Educational Needs AND belonged to the 1986 cohort.	2	0,074	0	1
language_reg	Dummy for whether individual had a mother tongue other than English. Missing values set to zero.	2	0,089	0	1
language_missing	Dummy for whether information on the individual's mother tongue was missing.	2	0,001	0	1
_Imob_2	Dummy for being born in February. Omitted category is January.	2	0,081	0	1
_Imob_3	Dummy for being born in March. Omitted category is January.	2	0,087	0	1
_Imob_4	Dummy for being born in April. Omitted category is January.	2	0,084	0	1
_Imob_5	Dummy for being born in May. Omitted category is January.	2	0,087	0	1
_Imob_6	Dummy for being born in June. Omitted category is January.	2	0,080	0	1
_Imob_7	Dummy for being born in July. Omitted category is January.	2	0,084	0	1
_Imob_8	Dummy for being born in August. Omitted category is January.	2	0,084	0	1
_Imob_9	Dummy for being born in September. Omitted category is January.	2	0,081	0	1

Variable	Description	Unique Values	Mean	Min	Max
female	Dummy for whether individual is female.	2	0,494	0	1
_Imob_10	Dummy for being born in October. Omitted category is January.	2	0,083	0	1
_Imob_11	Dummy for being born in November. Omitted category is January.	2	0,081	0	1
_Imob_12	Dummy for being born in December. Omitted category is January.	2	0,082	0	1

Table 2B-2: Explanatory Variables: Individual Attainment

Variable	Description	Unique Values	Mean	Min	Max
ks2_e_level_reg	Individual attainment in KS2 English test. Missing values set to zero.	259	3,818	0	6,58
ks2_e_level_miss	Dummy for whether individual attainment in KS2 English test is missing.	2	0,101	0	1
ks2_m_level_reg	Individual attainment in KS2 Mathematics test. Missing values set to zero.	271	3,821	0	6,90
ks2_m_level_miss	Dummy for whether individual attainment in KS2 Mathematics test is missing.	2	0,092	0	1
ks2_s_level_reg	Individual attainment in KS2 Science test. Missing values set to zero.	237	3,936	0	6,89
ks2_s_level_miss	Dummy for whether individual attainment in KS2 Science test is missing.	2	0,091	0	1
ks3_e_level_reg	Individual attainment in KS3 English test. Missing values set to zero.	240	4,954	0	9,73
ks3_e_level_miss	Dummy for whether individual attainment in KS3 English test is missing.	2	0,082	0	1
ks3_m_level_reg	Individual attainment in KS3 Mathematics test. Missing values set to zero.	1 122	5,407	0	9,95
ks3_m_level_miss	Dummy for whether individual attainment in KS3 Mathematics test is missing.	2	0,052	0	1
ks3_s_level_reg	Individual attainment in KS3 Science test. Missing values set to zero.	689	5,111	0	9,78
ks3_s_level_miss	Dummy for whether individual attainment in KS3 English test is missing.	2	0,055	0	1

Table 2B-3: Explanatory Variables: Year Group Socio-Demographics

Variable	Description	Unique Values	Mean	Min	Max
class_female	Proportion of year group who are female.	2 772	0,494	0	1,00
class_fsm_reg	Proportion of year group who are on Free School Meals. Missing values set to zero.	3 722	0,138	0	1,00
class_fsm_miss	Dummy if FSM information for entire year group is missing.	2	0,000	0	1
class_q1	Proportion of year group who come from 25% most deprived areas.	4 166	0,248	0	1,00
class_q2	Proportion of year group who come from 25% second most deprived areas.	4 216	0,248	0	1,00
class_q3	Proportion of year group who come from 25% second least deprived areas.	4 192	0,248	0	1,00
class_qm	Proportion of year group with missing information on area deprivation.	950	0,009	0	1,00
class_w_oth	Proportion of year group from White Other ethnic group.				
class_a_ind	Proportion of year group from Asian Indian ethnic group.	1 402	0,025	0	1,00
class_a_pak	Proportion of year group from Asian Pakistani ethnic group.	1 322	0,024	0	0,91
class_a_ban	Proportion of year group from Asian Bangladeshi ethnic group.	788	0,009	0	1,00
class_a_oth	Proportion of year group from Asian Other ethnic group.	540	0,003	0	0,29
class_b_car	Proportion of year group from Black Caribbean ethnic group.	1 193	0,014	0	0,82
class_b_afr	Proportion of year group from Black African ethnic group.	1 031	0,013	0	1,00
class_b_oth	Proportion of year group from Black Other ethnic group.	848	0,006	0	1,00
class_chi	Proportion of year group from Chinese ethnic group.	606	0,004	0	0,11
class_mix	Proportion of year group from Mixed ethnic group.	1 065	0,009	0	0,35
class_oth	Proportion of year group from Other ethnic group.	2 006	0,057	0	1,00
class_sen	Proportion of year group with Special Educational Needs.	3 731	0,160	0	0,86
class_language_reg	Proportion of year group with mother tongue other than English.	2 517	0,090	0	1,00
class_language_miss	Dummy if information on mother tongue us missing for entire year group.	2	0,000	0	1,00

Table 2B-4: Explanatory Variables: Year Group Attainment

Variable	Description	Unique Values	Mean	Min	Max
class_ks2_e_reg	Average KS2 English attainment of year group.	6 216	4,238	0	5,31
class_ks2_e_miss	Dummy for KS2 English attainment missing for entire year group.	2	0,000	0	1,00
class_ks2_m_reg	Average KS2 Mathematics attainment of year group.	6 219	4,201	0	5,71
class_ks2_m_miss	Dummy for KS2 Mathematics attainment missing for entire year group.	2	0,000	0	1,00
class_ks2_s_reg	Average KS2 Science attainment of year group.	6 213	4,322	0	5,29
class_ks2_s_miss	Dummy for KS2 Science attainment missing for entire year group.	2	0,000	0	1,00
class_ks3_e_reg	Average KS3 English attainment of year group.	6 220	5,377	0	7,78
class_ks3_e_miss	Dummy for KS3 English attainment missing for entire year group.	2	0,000	0	1,00
class_ks3_m_reg	Average KS3 Mathematics attainment of year group.	6 224	5,691	0	8,30
class_ks3_m_miss	Dummy for KS3 Mathematics attainment missing for entire year group.	2	0,000	0	1,00
class_ks3_s_reg	Average KS3 Science attainment of year group.	6 223	5,393	0	7,78
class_ks3_s_miss	Dummy for KS3 Science attainment missing for entire year group.	2	0,000	0	1,00

Table 2B-5: Explanatory Variables: School Resources

Variable	Description	Unique Values	Mean	Min	Max
yr11_fte_pupils_reg	Number of Full-Time Equivalent pupils in individual's school when s/he is in year 11.	1 543	1112,5	0	2624,0
yr11_fte_pupils_miss	Dummy if information on FTE pupils in individual's school is missing.	2	0,000	0	1,00
yr11_fte_qualteach_reg	Number of Full-Time Equivalent qualified teachers in individual's school when s/he is in year 11.	962	65,8	0	148,2
yr11_fte_qualteach_miss	Dummy if information on FTE qualified teachers in individual's school is missing.	2	0,000	0	1,00
yr11_fte_othteach_reg	Number of Full-Time Equivalent other teachers in individual's school when s/he is in year 11.	185	2,4	0	37,2
yr11_fte_othteach_miss	Dummy if information on FTE other teachers in individual's school is missing.	2	0,382	0	1,00
yr11_fte_tech_reg	Number of Full-Time Equivalent technicians in individual's school when s/he is in year 11.	146	5,1	0	21,8
yr11_fte_tech_miss	Dummy if information on FTE technicians in individual's school is missing.	2	0,146	0	1,00

Table 2B-6: Dependent Variables

Variable	Description	Unique Values	Mean	Min	Max
out_alevel	Whether individual attained equivalent of 2 Vocational or Academic A Level passes.	2	0,328	0	1,00
out_l3_bio	Whether individual took A Level Biology.	2	0,050	0	1,00
out_l3_bio_a	Whether individual attained a grade A in A Level Biology.	2	0,011	0	1,00
out_l3_che	Whether individual took A Level Chemistry.	2	0,036	0	1,00
out_l3_che_a	Whether individual attained a grade A in A Level Chemistry.	2	0,010	0	1,00
out_l3_mat	Whether individual took A Level Mathematics.	2	0,052	0	1,00
out_l3_mat_a	Whether individual attained a grade A in A Level Mathematics.	2	0,018	0	1,00
out_l3_phy	Whether individual took A Level Physics.	2	0,028	0	1,00
out_l3_phy_a	Whether individual attained a grade A in A Level Physics.	2	0,007	0	1,00
out_he_19	Whether individual is doing a 1st Degree at the age of 19.	2	0,279	0	1,00
out_russell_19	Whether the individual is studying in a Russell Group institution at 19.	2	0,058	0	1,00
out_stem_19	Whether the individual is studying a STEM 1st Degree at 19.	2	0,108	0	1,00
out_he_bio_19	Whether the individual is studying a 1st Degree in Biological Sciences at 19.	2	0,027	0	1,00
out_he_eng_19	Whether the individual is studying a 1st Degree in Engineering and Technology at 19.	2	0,011	0	1,00
out_he_mat_19	Whether the individual is studying a 1st Degree in Mathematics and Computer Science.	2	0,017	0	1,00
out_he_med_19	Whether the individual is studying a 1st Degree in Medicine, Dentistry and Veterinary Science at 19.	2	0,008	0	1,00
out_he_phy_19	Whether the individual is studying a 1st Degree in Physical Sciences in HE at 19.	2	0,012	0	1,00

Annex 2C: Identifying Schools That Offer Triple Science

The Department for Education classifies a school as offering Triple Science if at least one pupil in the school is observed to enter the separate sciences. Although the same method employed by the Department for Education is used throughout Chapter 2, we cannot be absolutely sure that schools classified as not having offered Triple Science did not offer the programme. This is because a school might be offering Triple Science but no pupil chooses to take it. As a result, in schools where a switch in the science curriculum is observed, we may simply be observing pupil take-up of Triple Science. In order to test the extent to which this affects the results, two robustness checks are run.

First, I verify whether, in schools that allegedly dropped Triple Science from their curriculum, there was an accompanying increase in the number of pupils taking Double Science (the next best alternative). Similarly, in schools that took on Triple Science, I check whether there was an associated drop in the number of pupils taking Double Science. We do indeed notice a decrease in the proportion of students attempting Double Science from 42.1% to 39.0% in schools that take on Triple Science. The proportion of pupils who take Triple Science in those schools is 4.6%. Similarly, in schools that initially offered Triple Science but then dropped it, we observe an increase in the proportion of pupils who take Double Science from 37.1% to 41.2%. The original proportion of pupils taking Triple Science in those schools was 3.0%. These results suggest that there is indeed a change in the science curriculum on offer in the schools looked at, and that changes in Triple Science status are not driven solely by measurement error.

As a second robustness check, the threshold for identifying schools which offer and do not offer Triple Science is raised. Rather than classifying schools according to whether at least one pupil took Triple Science, they are now classified according to whether at least two/three/four/five/six pupils took Triple Science. So the schools which go from not offering to offering Triple Science will need to have zero pupils registered as taking Triple Science in the first year, and then two/three/four/five/six pupils in the second year. Similarly, in schools which initially offered Triple Science but subsequently dropped it, there would need to have been two/three/four/five/six pupils taking Triple Science in the first year, and then none in the second year.

The analysis is re-run using these new definitions. The results are presented in Table 2C-1, which shows the coefficients on the "Triple Science" variable from the a set of regressions where the threshold for identifying schools that offer Triple Science is gradually increased from one to six. These results are different from the main results presented in Table 2-10. This was to be expected, as the effect of Triple Science is now being identified using variation within a different set of schools. Not only will some schools have dropped out of the analysis, others will now be included as "treatment" schools. Consider the case of a school which, in the first year, had ten pupils taking Triple Science, but which only had one in the second year. Previously, this school would have been classified as a school that offered Triple Science in both years. However, by raising the threshold above one, this school would now be classified as a school that offered Triple Science in the first year, but not in the second.

At some thresholds, the results suggest marginally significant effects on the likelihood of taking Biology, Chemistry, Physics and Mathematics at A Level; as well as on the likelihood of doing well in A Level Physics. Interestingly, we now find very strong effects of offering Triple Science on the likelihood that pupils will achieve A Levels, as well as on the likelihood of entering higher education. Overall, however, the conclusions drawn in the main body of the text are not contradicted, and Triple Science is found to have a positive effect on both subject choice and attainment.

Table 2C-1: Increasing the Threshold for Identifying Schools that Offer Triple Science

	Number of Pupils Required for the School to be Classified as Offering Triple Science					
	1	2	3	4	5	6
Two A Level Passes	0.00180	0.00431	0.00509	0.00649	0.00732	0,00926
	(0.00260)	(0.00322)	(0.00324)	(0.00326)**	(0.00329)**	(0.00328)***
Took A Level Biology (1)	0.00536	0.00697	0.00674	0.00803	0.00785	0,00671
	(0.00393)	(0.00464)	(0.00476)	(0.00474)*	(0.00482)	(0.00484)
Took A Level Chemistry (1)	0.00849	0.00682	0.00535	0.00540	0.00628	0,00658
	(0.00331)**	(0.00382)*	(0.00391)	(0.00390)	(0.00391)	(0.00382)*
Took A Level Physics (1)	0.00452	0.00360	0.00385	0.00421	0.00506	0,00378
	(0.00267)*	(0.00318)	(0.00323)	(0.00327)	(0.00329)	(0.00326)
Took A Level Mathematics (1)	0.0100	0.00720	0.00621	0.00629	0.00735	0,00616
	(0.00348)***	(0.00430)*	(0.00441)	(0.00439)	(0.00454)	(0.00448)
Grade A in A Level Biology (2)	0.00654	-0.00597	-0.00413	-0.00222	-0.00233	-0,00244
	(0.0101)	(0.0123)	(0.0129)	(0.0128)	(0.0131)	(0.0131)
Grade A in A Level Chemistry (2)	0.0130	0.0131	0.00945	0.0119	0.0133	0,0115
	(0.0127)	(0.0138)	(0.0143)	(0.0142)	(0.0146)	(0.0146)
Grade A in A Level Physics (2)	0.0319	0.0290	0.0224	0.0257	0.0255	0,0236
	(0.0143)**	(0.0170)*	(0.0176)	(0.0174)	(0.0177)	(0.0178)
Grade A in A Level Mathematics (2)	-0.00177	0.0112	0.0129	0.00949	0.00988	0,00798
	(0.0115)	(0.0136)	(0.0143)	(0.0148)	(0.0148)	(0.0146)
In HE at 19	0.00373	0.00689	0.00666	0.00712	0.00769	0,00899
	(0.00229)	(0.00282)**	(0.00290)**	(0.00288)**	(0.00292)***	(0.00295)***
In a Russell Group Institution at 19 (3)	0.00413	0.00330	0.00305	0.00407	0.00349	-0,000431
	(0.00448)	(0.00550)	(0.00568)	(0.00565)	(0.00571)	(0.00569)
STEM in HE at 19 (3)	0.00720	0.00515	0.00408	0.00328	0.00353	0,00307
	(0.00548)	(0.00634)	(0.00652)	(0.00647)	(0.00658)	(0.0064)

	Number of Pupils Required for the School to be Classified as Offering Triple Science					
	1	2	3	4	5	6
Biological Sciences in HE at 19 (3)	-0.00173	-0.00395	-0.00422	-0.00412	-0.00524	-0,00334
	(0.00343)	(0.00385)	(0.00398)	(0.00396)	(0.00403)	(0.00397)
Medicine, Dentistry and Veterinary Sciences in HE at 19 (3)	-0.000421	0.000212	0.0000591	-0.000770	-0.000622	-0,00113
	(0.00158)	(0.00184)	(0.00190)	(0.00189)	(0.00190)	(0.00188)
Physical Sciences in HE at 19 (3)	0.00160	0.000414	-0.000184	0.000921	0.00145	0,00137
	(0.00232)	(0.00275)	(0.00281)	(0.00283)	(0.00287)	(0.0028)
Engineering and Technology in HE at 19 (3)	0.00298	0.00428	0.00330	0.00274	0.00214	0,00174
	(0.00210)	(0.00237)*	(0.00244)	(0.00240)	(0.00245)	(0.00233)
Mathematics and Computer Science in HE at 19 (3)	-0.000457	-0.00152	-0.00120	-0.00200	-0.00236	-0,00272
	(0.00291)	(0.00324)	(0.00331)	(0.00328)	(0.00333)	(0.00335)
Number of Schools that Take on Triple Science	192	144	138	132	129	126
Number of Schools that Drop Triple Science	145	74	68	67	66	62

Notes: Table shows coefficients on the "Triple Science" variable for variants of specification (vii) in Table 2-10 where the number of pupils doing Triple Science needed for the school to be classified as offering Triple Science is gradually increased from 1 to 6. Note that the results in the first column correspond to those in column (vii) in Table 2-10.
* p<0.10 **<0.05 ***<0.01
(1) Conditional on having been entered for A Level or equivalent qualifications; (2) Conditional on having been entered for examination in the subject; (3) Conditional on being in HE at 19.

Annex 2D: Analysis on Sub-Sample of Pupils with Identical KS3 and KS4 Establishments

Table 2D-1: Effect of Being Offered Triple Science: Sub-Sample of Pupils with Identical KS3 and KS4 Establishments

		(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)
Two A Level Passes	Triple Science	0.121	0.0806	0.0224	0.0161	0.00705	0.00416	0.00195
	(s.e.)	(0.00687)***	(0.00516)***	(0.00240)***	(0.00232)***	(0.00216)***	(0.00213)*	(0.00269)
Took A Level Biology (1)	Triple Science	0.0218	0.0209	-0.00204	-0.00299	-0.00398	-0.00429	0.00378
	(s.e.)	(0.00332)***	(0.00321)***	(0.00260)	(0.00264)	(0.00266)	(0.00267)	(0.00399)
Took A Level Chemistry (1)	Triple Science	0.0256	0.0247	0.000858	0.000736	-0.000373	-0.000186	0.00697
	(s.e.)	(0.00311)***	(0.00293)***	(0.00209)	(0.00208)	(0.00210)	(0.00212)	(0.00327)**
Took A Level Physics (1)	Triple Science	0.0301	0.0223	0.00461	0.00494	0.00513	0.00508	0.00409
	(s.e.)	(0.00278)***	(0.00227)***	(0.00171)***	(0.00169)***	(0.00167)***	(0.00169)***	(0.00269)
Took A Level Mathematics (1)	Triple Science	0.0417	0.0336	-0.00201	-0.0000842	0.00326	0.00327	0.00991
	(s.e.)	(0.00409)***	(0.00349)***	(0.00239)	(0.00234)	(0.00230)	(0.00229)	(0.00354)***
Grade A in A Level Biology (2)	Triple Science	0.0700	0.0662	0.00890	0.00855	0.00864	0.00994	0.00618
	(s.e.)	(0.00770)***	(0.00728)***	(0.00501)*	(0.00489)*	(0.00477)*	(0.00482)**	(0.0102)
Grade A in A Level Chemistry (2)	Triple Science	0.0889	0.0800	0.0209	0.0204	0.0181	0.0190	0.0112
	(s.e.)	(0.00943)***	(0.00892)***	(0.00659)***	(0.00635)***	(0.00620)***	(0.00625)***	(0.0131)
Grade A in A Level Physics (2)	Triple Science	0.0843	0.0775	0.0105	0.00962	0.00957	0.0107	0.0304
	(s.e.)	(0.00927)***	(0.00898)***	(0.00601)*	(0.00611)	(0.00597)	(0.00596)*	(0.0145)**
Grade A in A Level Mathematics (2)	Triple Science	0.0748	0.0682	0.00299	-0.000473	-0.000811	-0.000243	-0.00249
	(s.e.)	(0.00875)***	(0.00827)***	(0.00565)	(0.00569)	(0.00580)	(0.00583)	(0.0117)
In HE at 19	Triple Science	0.103	0.0725	0.0234	0.0167	0.00442	0.00303	0.00344
	(s.e.)	(0.00631)***	(0.00481)***	(0.00238)***	(0.00223)***	(0.00191)**	(0.00191)	(0.00242)
In a Russell Group Institution at 19 (3)	Triple Science	0.0696	0.0571	0.0172	0.0102	0.00105	0.00132	0.00382
	(s.e.)	(0.00605)***	(0.00564)***	(0.00364)***	(0.00339)***	(0.00329)	(0.00327)	(0.00454)

		(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)
STEM in HE at 19 (3)	Triple Science	0.00882	0.00255	-0.00941	-0.00411	-0.000115	0.000837	0.00678
	(s.e.)	(0.00296)***	(0.00286)	(0.00285)***	(0.00279)	(0.00278)	(0.00278)	(0.00563)
Biological Sciences in HE at 19 (3)	Triple Science	-0.000369	-0.00124	-0.00312	-0.00187	-0.0000163	0.000177	-0.00185
	(s.e.)	(0.00143)	(0.00140)	(0.00142)**	(0.00145)	(0.00149)	(0.00149)	(0.00348)
Medicine, Dentistry and Veterinary Sciences in HE at 19 (3)	Triple Science	0.00825	0.00791	0.00207	0.000895	-0.000954	-0.000698	-0.000670
	(s.e.)	(0.00123)***	(0.00119)***	(0.000946)**	(0.000913)	(0.000919)	(0.000921)	(0.00158)
Physical Sciences in HE at 19 (3)	Triple Science	0.00617	0.00252	-0.00207	-0.00102	0.000126	0.000206	0.00166
	(s.e.)	(0.00113)***	(0.00102)**	(0.00101)**	(0.00100)	(0.000999)	(0.00101)	(0.00241)
Engineering and Technology in HE at 19 (3)	Triple Science	0.00482	0.00107	-0.000899	-0.000135	0.000472	0.000654	0.00304
	(s.e.)	(0.00120)***	(0.000952)	(0.000937)	(0.000923)	(0.000923)	(0.000924)	(0.00211)
Mathematics and Computer Science in HE at 19 (3)	Triple Science	-0.00455	-0.00485	-0.00531	-0.00172	0.000460	0.000506	-0.00112
	(s.e.)	(0.00138)***	(0.00122)***	(0.00123)***	(0.00114)	(0.00115)	(0.00115)	(0.00296)

Notes: Table reproduces Table 2-10 on sub-sample of pupils for whom the KS3 and KS4 establishments were the same.
* p<0.10 **<0.05 ***<0.01
(1) Conditional on having been entered for A Level or equivalent qualifications; (2) Conditional on having been entered for examination in the subject; (3) Conditional on being in HE at 19.

Annex 2E: Effect of Triple Science on English

As a falsification exercise to test the robustness of the results obtained in Chapter 2, this annex looks at what effect offering Triple Science has on the take-up of, and attainment in, English at A Level (English, English Language and English Literature[68]).

The effect of Triple Science on the take-up of English is relatively straightforward to analyse from a theoretical perspective. If offering Triple Science makes pupils more likely to choose science subjects at A Level, then this will have to come at the expense of some other subject. This could be English (in which case we would expect the effect of offering Triple Science on the take-up of English to be negative) or some other, more "marginal" subjects like History, Geography, Economics or Psychology (in which case the effect on English should be zero). Either way, we would not expect the effect to be positive: it would be counter-intuitive if offering Triple Science increased the take-up of English at A Level, and this would throw doubt on the results obtained in this chapter.

The effect of offering Triple Science on attainment in English is more difficult to predict. It could be positive if the more intensive study of sciences increases pupils' ability all-round and has positive spill-over effects on other subjects outside Science and Mathematics. It could also be negative if offering Triple Science leads the brightest students to study science at A Level, leaving the slightly lesser able ones to study English. A negative effect could also result from pupils having to drop non-science subjects in favour of science subjects, so they are less well prepared for the study of non-science subjects at a higher level.

Table 2E-1 below presents the coefficients on the "Triple Science" variable in regressions similar to specification (vii) in Table 2-10 but where the outcome variables are now: (i) the likelihood of taking the various English A Levels and (ii) attainment in those A Levels conditional on having taken them. The results are encouraging: not one is statistically significant. The results on attainment in English mostly suggest no effect at all, although there is a marginally significant (10% confidence level) and negative effect on the likelihood of attaining a Grade A in English.

[68] There are three different options available for studying English at A Level: English Literature, English Language, or English (which is a combination of English Language and English Literature into one subject).

Table 2E-1: Effect of Triple Science on Take-up of, and Attainment in, English at A Level

Took A Level English (1)	Triple Science	-0.00114
	(s.e.)	(0.00323)
Took A Level English Literature (1)	Triple Science	-0.000593
	(s.e.)	(0.00459)
Took A Level English Language (1)	Triple Science	-0.000428
	(s.e.)	(0.00375)
Grade A in A Level English (2)	Triple Science	-0.0241
	(s.e.)	(0.0137)*
Grade A in A Level English Literature (2)	Triple Science	-0.0132
	(s.e.)	(0.00984)
Grade A in A Level Language (2)	Triple Science	-0.00140
	(s.e.)	(0.0110)

* p<0.10 **<0.05 ***<0.01

(1) Conditional on having been entered for A Level or equivalent qualifications.

(2) Conditional on having been entered for examination in the subject.

Notes: Table shows coefficients on Triple Science for a series of regressions similar to those in specification (vii) of Table 2-10, but where the outcome variables are now the likelihood of taking English A Levels, and of attaining a grade A in them.

Annex 3A: Typical Entry Requirements for Courses at Royal Holloway, University of London

Course	Grade Combination Required	Specific Requirements
Ancient History (V110)	ABB	
Ancient History and Philosophy (VV15)	ABB	
Ancient History with Philosophy (V1V5)	ABB	
Applied Physics (F313)	AAB-ABB	Mathematics and Physics
Astrophysics (F510)	AAB-ABB	Mathematics and Physics
Astrophysics (F511)	AAB-ABB	Mathematics and Physics
Biochemistry (C700)	ABB	Biology at grade B and Chemistry at grade B
Biology (C100)	ABB	Biology at grade B and Any Science subject
Biology with Psychology (C1C8)	ABB	Biology at grade B and Any Science subject
Biomedical Sciences (B990)	ABB	Biology at grade B and Chemistry at grade B
Classical Studies (Q810)	ABB	
Classical Studies and Drama (QW84)	AAB	
Classical Studies and Italian (QR73)	ABB	Italian or European Language
Classical Studies and Philosophy (QV8M)	BBB	
Classical Studies with Philosophy (Q9V5)	ABB	
Classics (Q800)	ABB	Latin at grade B or Classical Greek at grade B
Classics and Philosophy (QV85)	ABB	Latin at grade B or Classical Greek at grade B
Classics with Philosophy (Q8V5)	ABB	Latin at grade B or Classical Greek at grade B
Comparative Literature & Culture and English (QQ23)	ABB	English at grade A
Comparative Literature & Culture and French (QR21)	ABB-BBB	French at grade B
Comparative Literature & Culture and German (QR22)	ABB-BBB	German at grade B
Comparative Literature & Culture and Hispanic St (QR24)		Spanish at grade B or European Language at grade B or Latin at grade B
Comparative Literature & Culture and Italian (QR23)		Italian at grade B or European Language at grade B or Latin at grade B
Comparative Literature & Culture and Philosophy (QV25)	ABB-BBB	Including at least one language or essay-based subject
Comparative Literature & Culture with Film St (Q2P3)	ABB-BBB	Including at least one language or essay-based subject
Comparative Literature & Culture with Philosophy (Q2V5)	ABB-BBB	Including at least one language or essay-based subject
Comparative Literature and Culture (Q200)	ABB-BBB	Including at least one language or essay-based subject

Course	Grade Combination Required	Specific Requirements
Computer Science (G400)	ABC/BBB	Including a Mathematical based Science subject
Computer Science (Artificial Intelligence) (G4G7)	ABB	Including a Mathematical based Science subject
Computer Science (Year in Industry) (G402)	ABB	Including a Mathematical based Science subject
Computer Science and Mathematics (GG41)	ABB	Mathematics at grade A
Computer Science with French (G4R1)	ABC/BBB	Including grade B in French plus grade C in a Mathematical based Science subject
Computer Science with Management (G4N2)	ABC/BBB	Including a Mathematical based Science subject
Computing and Business (GN41)	ABB	Including a Mathematical based Science subject
Criminology and Sociology (LM39)	BBB	
Drama and Creative Writing (WW48)	AAB	
Drama and German (WR42)	ABB	German at grade B or European Language at grade B or Latin at grade B
Drama and Italian (WR43)	ABB	Modern Foreign Language at grade B
Drama and Music (WW43)	ABB	Music at grade A
Drama and Philosophy (WV45)	AAB	
Drama and Theatre Studies (W440)	AAB	
Drama with Philosophy (W4V5)	AAB	
Ecology and Environment (C150)	ABB	Biology at grade B and Any Science subject
Economics (L101)		ABB required if including Mathematics, or AAB with AS Mathematics at grade B, or AAA with GCSE Mathematics at grade A
Economics and Management (LN12)		ABB required if including Mathematics, or AAB with AS Mathematics at grade B, or AAA with GCSE Mathematics at grade A
Economics and Mathematics (LG11)	AAB	Mathematics at grade A
Economics with French (L1R1)		Grades ABB required if including Mathematics and French, or AAB including French with AS Mathematics at grade B, or AAA including French with GCSE Mathematics at grade A
Economics with German (L1R2)		Grades ABB required if including Mathematics and German (or European Language or Latin), or AAB including German (or European language or Latin) with AS Mathematics at grade B, or AAA including German (or European Language or Latin) with GCSE Mathematics at grade A
Economics with Italian (L1R3)		Grades ABB required if including Mathematics and Italian (or European Language), or AAB including Italian (or European language) with AS Mathematics at grade B, or AAA including Italian (or European Language) with GCSE Mathematics at grade A

Course	Grade Combination Required	Specific Requirements
Economics with Music (L1W3)		Grades ABB required if including Music grade A and Mathematics, or AAB including Music grade A with AS Mathematics at grade B, or AAA including Music grade A with GCSE Mathematics at grade A.
Economics with Political Studies (L1L2)		Grades ABB required if including Mathematics, or AAB with AS Mathematics at grade B, or AAA with GCSE Mathematics at grade A.
Economics with Spanish (L1R4)		Grades ABB required if including Mathematics and Spanish, or AAB including Spanish with AS Mathematics at grade B, or AAA including Spanish with GCSE Mathematics at grade A.
Economics, Politics & International Relations (LL12)		Grades ABB required if including Mathematics, or AAB with AS Mathematics at grade B, or AAA with GCSE Mathematics at grade A.
English (Q300)	AAB	English at grade A
English and Classical Studies (QQ38)	ABB	English at grade A
English and Creative Writing (QW38)	AAB	English at grade A
English and Drama (QW34)	AAB	English at grade A
English and French (QR31)	ABB	English at grade A and French at grade B
English and German (QR32)		English at grade A and (German at grade B or European Language at grade B or Latin at grade B)
English and Italian (QR33)	ABB	English at grade A and European Language at grade B.
English and Latin (QQ36)	ABB	English at grade A and Latin at grade B
English and Philosophy (QV35)	AAB	English at grade A
English and Spanish (QR34)	ABB	English at grade A and (Spanish at grade B or European Language at grade B or Latin at grade B)
English with Philosophy (Q3V5)	AAB	English at grade A
Environmental Geology (F630)	BBB	Any Science subject at grade B
Environmental Geology with a Year in Industry (F690)	BBB	Any Science subject at grade B
Environmental Geoscience (F631)	ABB	Any Science subject at grade B
Environmental Geoscience with Year in Industry (F644)	ABB	Any Science subject at grade B
European Studies (French) (R100)	ABB	French at grade B
European Studies (German) (R200)	ABB	German at grade B or European Language at grade B or Latin at grade B
European Studies (Italian) (R300)	ABB	Italian at grade B or European Language at grade B or Latin at grade B
European Studies (Spanish) (R401)	ABB	Spanish at grade B or European Language at grade B or Latin at grade B
Film & Television Studies with Philosophy (W6V5)	ABB	

Course	Grade Combination Required	Specific Requirements
Film and Television (W620)	ABB	
Finance and Mathematics (NG31)	AAB	Mathematics at grade A
Financial and Business Economics (L111)	AAA-ABB	Mathematics at grade B
French (4 years) (R120)	ABB-BBB	French at grade B
French and Classical Studies (RQ18)	ABB	French at grade B
French and Drama (RW14)	ABB	French at grade B
French and German (RR12)	ABB-BBB	French at grade B and (German at grade B or European Language at grade B or Latin at grade B)
French and Greek (RQ17)	ABB	French at grade B and Classical Greek at grade B
French and History (RV11)	ABB	French at grade B
French and Italian (RR13)	ABB-BBB	French at grade B
French and Latin (RQ16)	ABB	French at grade B and Latin at grade B
French and Management (RN12)	ABB	French at grade B
French and Music (RW13)	ABB	French at grade B and Music at grade A
French and Philosophy (RV15)	ABB-BBB	French at grade B
French and Spanish (RR14)	ABB-BBB	French at grade B and Spanish at grade B
French with Film Studies (R1P3)	ABB-BBB	French at grade B
French with German (R1R2)	ABB-BBB	French at grade B and (German at grade B or European Language at grade B or Latin at grade B)
French with International Relations (R1LF)	ABB-BBB	French at grade B
French with Italian (R1R3)	ABB-BBB	French at grade B
French with Mathematics (R1G1)	ABB	French at grade B and Mathematics at grade A
French with Music (R1W3)	ABB	French at grade B and Music at grade B
French with Philosophy (R1V5)	ABB-BBB	French at grade B
French with Political Studies (R1L2)	ABB-BBB	French at grade B
French with Spanish (R1R4)	ABB-BBB	French at grade B and Spanish at grade B
Geography (F800)	ABB	Geography at grade B
Geography (L700)	ABB	Geography at grade B
Geography, Politics and International Relations (FL82)	AAB	Geography at grade B
Geology (F600)	BBB	Any Science subject at grade B

Course	Grade Combination Required	Specific Requirements
Geology with a Year in Industry (F603)	BBB	Any Science subject at grade B
Geoscience (F601)	ABB	Any Science subject at grade B
Geoscience with a Year in Industry (F642)	ABB	Any Science subject at grade B
Geoscience with A Year of International Study (F602)	AAB	Any Science subject
German (R220)	ABB-BBB	German at grade B
German and Classical Studies (RQ28)	ABB	German at grade B or European Language at grade B or Latin at grade B
German and Greek (RQ27)	ABB	Classical Greek at grade B and (German at grade B or European Language at grade B or Latin at grade B)
German and History (RV21)	ABB	German at grade B or European Language at grade B or Latin at grade B
German and Italian (RR23)	ABB-BBB	German at grade B and Italian at grade B. (European Language at grade B or Latin at grade B)
German and Latin (RQ26)	ABB	German at grade B and Latin at grade B
German and Management (RN22)	ABB	German at grade B or European Language at grade B or Latin at grade B
German and Music (RW23)	ABB	Music at grade A and (German at grade B or European Language at grade B or Latin at grade B)
German and Philosophy (RV25)	ABB-BBB	German at grade B
German and Spanish (RR24)	ABB-BBB	German at grade B and Spanish at grade B
German with Film Studies (R2P3)	ABB-BBB	German at grade B
German with French (R2R1)	ABB-BBB	German at grade B and French at grade B
German with History (R2V1)	ABB-BBB	German at grade B
German with International Relations (R2LF)	ABB-BBB	German at grade B
German with Italian (R2R3)	ABB-BBB	German at grade B
German with Mathematics (R2G1)	ABB	German at grade B and Mathematics at grade A
German with Music (R2W3)	ABB-BBB	German at grade B and Music at grade B
German with Philosophy (R2V5)	ABB-BBB	German at grade B
German with Political Studies (R2L2)	ABB-BBB	German at grade B
German with Spanish (R2R4)	ABB-BBB	German at grade B and Spanish at grade B
Greek (Q700)	ABB	Classical Greek at grade B
Greek and Italian (QR7H)	ABB	Classical Greek at grade B
History (V100)	AAB	
History and International Relations (VL12)	AAB	

Course	Grade Combination Required	Specific Requirements
History and Music (VW13)	ABB	Music at grade A
History and Spanish (VR14)	AAB	
History with an International Year (4 Years) (V101)	AAB	
History with Spanish (V1R4)	AAB	Spanish at grade B
Human Geography (L701)	ABB	Geography at grade B
International Theatre (Australia) (W423)	AAB	
Italian (R310)	ABB-BBB	Italian at grade B or European Language at grade B or Latin at grade B
Italian and Latin (RQ36)	ABB	Italian or Modern Foreign Language. Latin
Italian and Management (RN32)	ABB	Italian at grade B or European Language at grade B or Latin at grade B
Italian and Music (RW33)	ABB	Music at grade A and (Italian or European Language or Latin at grade B)
Italian and Philosophy (RV35)	ABB-BBB	Italian at grade B or European Language at grade B or Latin at grade B
Italian and Spanish (RR34)	ABB-BBB	Spanish at grade B and Italian at grade B. (European Language at grade B or Latin at grade B)
Italian with Film Studies (R3P3)	ABB-BBB	Italian at grade B or European Language at grade B or Latin at grade B
Italian with French (R3R1)	ABB-BBB	French at grade B.
Italian with German (R3R2)	ABB-BBB	German at grade B.
Italian with International Relations (R3LF)	ABB-BBB	Italian at grade B or European Language at grade B or Latin at grade B
Italian with Mathematics (R3G1)	ABB	Mathematics at grade A and (Italian or European Language or Latin at grade B)
Italian with Music (R3W3)	ABB-BBB	Music and (Italian or European Language or Latin at grade B)
Italian with Philosophy (R3V5)	ABB-BBB	Italian at grade B or European Language at grade B or Latin at grade B
Italian with Political Studies (R3L2)	ABB-BBB	Italian at grade B or European Language at grade B or Latin at grade B
Italian with Spanish (R3R4)	ABB-BBB	Spanish at grade A
Latin (Q600)	ABB	Latin at grade B
Management (N200)	AAB	
Management and Spanish (NR24)	ABB	Spanish at grade B or European Language at grade B or Latin at grade B
Management with Accounting (N2N4)	AAB	
Management with Human Resources (N2N6)	AAB	
Management with Information Systems (N2G5)	AAB	
Management with International Business (N2N1)	AAB	
Management with Marketing (N2N5)	AAB	
Management with Mathematics (N2G1)	AAB	Mathematics at grade A

Course	Grade Combination Required	Specific Requirements
Mathematics (G100)	AAB	Mathematics at grade A
Mathematics (G103)	AAB	Mathematics at grade A
Mathematics and Management (GN12)	AAB	Mathematics at grade A
Mathematics and Music (GW13)	AAB	Mathematics at grade A and Music at grade A
Mathematics and Physics (GF13)	AAB	Mathematics at grade A. Physics at grade A
Mathematics and Physics (GFC3)	AAB	Mathematics at grade A. Physics at grade A
Mathematics and Psychology (GC18)	AAB	Mathematics at grade A
Mathematics with French (G1R1)	ABB	Mathematics at grade A and French at grade B.
Mathematics with German (G1R2)	ABB	Mathematics at grade A and (German at grade B or European Language at grade B or Latin at grade B)
Mathematics with Italian (G1R3)	ABB	Mathematics at grade A and European Language at grade B.
Mathematics with Management (G1N2)	AAB	Mathematics at grade A
Mathematics with Philosophy (G1V5)	ABB	Mathematics at grade A
Mathematics with Spanish (G1R4)	ABB	Mathematics at grade A and Spanish at grade B.
Mathematics with Statistics (G1G3)	AAB	Mathematics at grade A
Media Arts (W625)	ABB	
Medical Biochemistry (C741)	ABB	Biology at grade B and Chemistry at grade B
Modern History and Politics (V136)	AAB	
Molecular Biology (C701)	ABB	Biology at grade B and Chemistry at grade B
Multilingual St with International Relations (Q1L2)	ABB-BBB	Two Languages from French, German, Italian or Spanish at grade B
Multilingual Studies (R991)	ABB-BBB	Two Languages from French, German, Italian or Spanish at grade B
Multilingual Studies with Philosophy (R9VM)	ABB-BBB	Two Modern European Languages at grade B
Music (W302)	ABB	Music at grade A.
Music and Philosophy (WV35)	ABB	Music at grade A.
Music with French (W3R1)	ABB	Music at grade A and French at grade B
Music with German (W3R2)	ABB	Music at grade A and (German at grade B or European Language at grade B or Latin at grade B)
Music with Italian (W3R3)	ABB	Music at grade A and (Italian at grade B or European Language at grade B or Latin at grade B).
Music with Philosophy (W3V5)	ABB	Music at grade A

Course	Grade Combination Required	Specific Requirements
Music with Political Studies (W3L2)	ABB	Music at grade A
Music with Psychology (W3C8)	ABB	Music at grade A
Music with Spanish (W3R4)	ABB	Music at grade A and Spanish at grade B
Petroleum Geology (F620)	BBB	Any Science subject at grade B
Petroleum Geology (F622)	ABB	Any Science subject at grade B
Physical Geography (F840)	ABB	Geography at grade B
Physical Geography and Geology (FF68)	ABB	Any Science subject at grade B
Physics (F300)	AAB-ABB	Mathematics and Physic
Physics (F303)	AAB-ABB	Mathematics and Physic
Physics with Music (F3W3)	AAB-ABB	Mathematics at grade B and Physics at grade B and Music at grade A
Physics with Particle Physics (F370)	AAB-ABB	Mathematics and Physic
Physics with Particle Physics (F372)	AAB-ABB	Mathematics and Physic
Physics with Philosophy (F3V5)	AAB-ABB	Mathematics and Physic
Politics (L200)	AAB	
Politics and International Relations (L290)	AAB	
Politics and Philosophy (LV25)	ABB	
Politics with Philosophy (L2V5)	AAB	
Psychology (C800)	AAB	
Science Foundation - Option: Biochemistry (C708)		
Science Foundation - Option: Biological Sciences (C908)		
Science Foundation - Option: Biomedical Sciences (B908)		
Science Foundation - Option: Computer Science (G408)		
Science Foundation - Option: Geography (F808)		
Science Foundation - Option: Geology (F608)		
Science Foundation - Option: Mathematics (G108)		
Science Foundation - Option: Physics (F308)		
Science Foundation - Option: Psychology (C808)		
Spanish (R400)	ABB-BBB	Spanish at grade B or European Language at grade B or Latin at grade B
Spanish and Philosophy (RV45)	ABB-BBB	Spanish at grade B or European Language at grade B or Latin at grade B
Spanish with Film Studies (R4P3)	ABB-BBB	Spanish at grade B or European Language at grade B or Latin at grade B

Course	Grade Combination Required	Specific Requirements
Spanish with French (R4R1)	ABB-BBB	French at grade B and Spanish at grade B
Spanish with German (R4R2)	ABB-BBB	German at grade B and Spanish at grade B
Spanish with History (R4V1)	ABB-BBB	Spanish at grade B or European Language at grade B or Latin at grade B.
Spanish with International Relations (R4L2)	ABB-BBB	Spanish at grade B or European Language at grade B or Latin at grade B
Spanish with Italian (R4R3)	ABB-BBB	Spanish at grade B and Italian at grade B. (European Language at grade B or Latin at grade B)
Spanish with Music (R4W3)	ABB-BBB	Music at grade B and Spanish at grade B
Spanish with Philosophy (R4V5)	ABB-BBB	Spanish at grade B or European Language at grade B or Latin at grade B
Theoretical Physics (F321)	AAB-ABB	Mathematics and Physics
Theoretical Physics (F340)	AAB-ABB	Mathematics and Physics
Zoology (C300)	ABB	Biology at grade B and Any Science subject

Annex 3B: Do Observable Characteristics Predict: (i) Who Takes Up Their Firm Offer; and (ii) Earnings?

Table 3B-1: Do Observable Characteristics Predict: (i) Who Takes Up Their Firm Offer; and (ii) Earnings?

	Firm Offer	Log Earnings
Tariff Score	0.000395	0.000367
	(0.0000474)***	(0.0000581)***
Tariff Score Missing	0.127	0.108
	(0.0298)***	(0.0300)***
University Selectivity		0.0613
		(0.00677)***
Female	-0.000553	-0.105
	(0.0108)	(0.0106)***
Ethnicity - White British	0.00600	-0.0952
	(0.0415)	(0.0405)*
Ethnicity - White Irish	0.0225	-0.0339
	(0.0529)	(0.0515)
Ethnicity - White Scottish	-0.0494	-0.334
	(0.112)	(0.109)**
Ethnicity - Irish Traveller	0.153	0.409
	(0.315)	(0.306)
Ethnicity - Black Caribbean	0.0184	-0.0783
	(0.0551)	(0.0537)
Ethnicity - Black African	-0.00456	0.0102
	(0.0536)	(0.0522)
Ethnicity - Other Black	-0.138	-0.210
	(0.118)	(0.115)
Ethnicity - Asian Indian	-0.0207	0.0361
	(0.0468)	(0.0456)
Ethnicity - Asian Pakistani	-0.0221	-0.0824
	(0.0580)	(0.0565)
Ethnicity - Asian Bangladeshi	0.0212	0.0637
	(0.0699)	(0.0681)
Ethnicity – Asian Chinese	-0.0610	0.00992
	(0.0608)	(0.0592)
Ethnicity - Other Asian	-0.0415	-0.0268
	(0.0639)	(0.0623)
Ethnicity - Mixed White and Black Caribbean	-0.0248	-0.118
	(0.0762)	(0.0742)
Ethnicity - Mixed White and Black African	0.0516	-0.125
	(0.0991)	(0.0966)
Ethnicity – Mixed White and Asian	-0.0314	-0.123
	(0.0580)	(0.0565)*
Ethnicity - Other Mixed	-0.0775	0.0341
	(0.0632)	(0.0615)

Ethnicity - Not known	-0.0214	-0.0584
	(0.0539)	(0.0525)
2nd Most Deprived IMD Quartile	-0.0220	0.00743
	(0.0167)	(0.0163)
2nd Least Deprived IMD Quartile	0.00240	0.00844
	(0.0169)	(0.0165)
Least Deprived IMD Quartile	-0.0272	0.0472
	(0.0232)	(0.0226)*
IMD Information Missing	0.0472	0.0483
	(0.0430)	(0.0419)
SEC - Lower Managerial and Professional	-0.0152	0.0137
	(0.0146)	(0.0142)
SEC - Intermediate	-0.00556	0.0143
	(0.0179)	(0.0174)
SEC - Small Employers and Own Account Workers	0.0255	-0.0407
	(0.0240)	(0.0234)
SEC - Lower Supervisory and Technical	0.00688	-0.00832
	(0.0280)	(0.0273)
SEC - Semi-Routine Occupations	0.0227	0.00218
	(0.0210)	(0.0205)
SEC - Routine	0.0223	-0.0420
	(0.0284)	(0.0278)
SEC - Not Classified	-0.0142	-0.0365
	(0.0221)	(0.0216)
Born February	0.0168	-0.00508
	(0.0267)	(0.0260)
Born March	-0.0292	0.00682
	(0.0258)	(0.0251)
Born April	0.0198	-0.0350
	(0.0258)	(0.0251)
Born May	-0.0397	-0.0184
	(0.0251)	(0.0245)
Born June	-0.00327	-0.0143
	(0.0255)	(0.0249)
Born July	0.0153	-0.0157
	(0.0251)	(0.0245)
Born August	-0.0307	-0.0222
	(0.0263)	(0.0256)
Born September	-0.00183	-0.0189
	(0.0253)	(0.0247)
Born October	-0.00604	0.0152
	(0.0266)	(0.0259)
Born November	-0.0205	0.00647
	(0.0253)	(0.0247)
Born December	-0.0218	-0.0107
	(0.0259)	(0.0252)
Disabled	0.0369	-0.0507
	(0.0215)	(0.0209)*

Age (Years)	0.00569	0.00725
	(0.00225)*	(0.00219)***
Domicile - Other UK	-0.0357	-0.196
	(0.0288)	(0.0281)***
Domicile – Overseas	-0.0333	-0.0839
	(0.0408)	(0.0397)*
Previous Institution - Further Education	0.0456	-0.0177
	(0.0170)**	(0.0166)
Previous Institution - Higher Education	-0.0917	-0.183
	(0.157)	(0.153)
Previous Institution - Independent School	-0.0284	0.0870
	(0.0169)	(0.0167)***
Previous Institution - Not Known	0.0189	0.139
	(0.0392)	(0.0382)***
N	3537	3537

Standard errors in parentheses

* p<0.05 ** p<0.01 *** p<0.001

Notes: Table shows results of a regression where the dependent variable is (i) a dummy variable taking the value of one if the individual has taken up his/her insurance offer; and (ii) log earnings. Omitted categories include: Male, Ethnicity - White Other, Most Deprived IMD Quartile, SEC - Higher Managerial and Professional, Born January, Non-Disabled, Domicile – England, Previous Institution – State School. IMD = Index of Multiple Deprivation (measure of area deprivation). SEC = Socio-Economic Class.

Annex 3C: Chapter 3 Data Appendix

This annex explains how the main sample for analysis in Chapter 3 was derived. The starting point was the second Longitudinal Destinations of Leavers from Higher Education (LDLHE) survey. This is a survey of graduates who left higher education in 2004/05 and who were contacted in winter 2008/09. The survey contains key information on employment status, annual salary, industry and occupation of employment, additional qualifications obtained since graduating in 2004/05, as well as answers to a range of career satisfaction questions. Around 161,000 graduates from 158 institutions were contacted, achieving a total of 41,397 responses (a 26% response rate).

UCAS records for 13,223 of these could be linked on. The remaining observations could not be linked for the following reasons. According to their HESA record, 18,039 individuals never applied through UCAS: 10,845[69] of these were postgraduates and another 3,558 individuals were part-time undergraduates – neither of these apply through UCAS which is a system designed for full-time undergraduate students only. Another 3,636 individuals were recorded as not having entered through UCAS despite being neither a postgraduate nor a part-time undergraduate. Some of this will be due to error in the HESA variable which records whether the individual was a UCAS entrant or not. More importantly, however, it became clear from discussions with UCAS officials that not all full-time undergraduates do in fact apply through UCAS – particularly individuals who attend local institutions. No estimate of the number of full-time undergraduates who do not apply through UCAS was available.

Besides the 18,039 individuals who did not apply through UCAS, there were another 10,135 individuals who did apply through UCAS, but for whom there was no UCAS record. The main reason for this is that I only had access to UCAS records going back to entry in 2002/03. Given that the LDLHE surveyed people who graduated in 2004/05, I could therefore only link in UCAS records for people who were on courses of a length no longer than three years and who completed within three years of starting. 6,917 individuals for whom no UCAS record could be found were indeed on courses of an expected length longer than three years, and so could not be matched to their UCAS record. The remaining observations without UCAS record (n=3,218) were likely to have

[69] 1,125 of these do apply through one of UCAS' applications systems (the Graduate Teacher Training Registry) – but as these are also postgraduate students, we have no information on their undergraduate course or institution.

been individuals who had taken longer than three years to graduate and so, despite being in the 2004/05 leaving cohort, they had probably entered the system prior to 2002/03.

This left 13,223 survey respondents with UCAS records matched on. Some further observations had to be removed: 666 observations because they had no information on institution applied to, and one more observation because s/he had two insurance offers. Only 9,292 individuals were in full-time work at the time of the survey, and I decided to keep an additional 791 who were in work and further study and had very similar salaries to those in full-time work (the results obtained in Chapter 3 do not change if those in work and further study are excluded from the analysis). A further 1,434 observations had to be deleted because of missing salary information, and the dataset was trimmed to include only individuals who earned between £10,000 and £100,000. Finally, all those attending the Scottish Agricultural College had to be deleted because of missing quality information (n=6) and another 659 information cases were not accepted at any of their institutions (but mentioned to get into higher education through a process called "Clearing"). This left 7,741 observations.

The final two steps included dropping 2,984 observations without an insurance offer and a further 1,220 observations that could not be matched to any other observation with the same firm and insurance choices. This left a final sample size of 3,537 observations.

Annex 3D: University Quality Measure

Table 3D-1: Components of the Quality Index (Non-Normalised) – Descriptive Statistics

Variable	Number of Institutions	Mean	Std. Dev.	Min	Max
Expenditure per Student	145	7.34	5.06	1.37	36.21
Academic Staff/Student Ratio	145	0.05	0.03	0.00	0.25
Non-Continuation Rate	145	8.42	4.51	1.30	31.30
Applications/Acceptance Ratio	145	5.44	2.01	1.71	15.53
Average Tariff Score of Entrants	145	195.25	89.89	12.71	485.16

Table 3D-2: Components of the Quality Index (Normalised) – Correlation Matrix

	Expenditure per Student	Academic Staff/Student Ratio	Non-Continuation Rate	Applications/Acceptance Ratio	Average Tariff Score of Entrants	Quality Index
Expenditure per Student	1					
Academic Staff/Student Ratio	0.9377	1				
Non-Continuation Rate	-0.3981	-0.4312	1			
Applications/Acceptance Ratio	0.3386	0.3691	-0.4084	1		
Average Tariff Score of Entrants	0.6331	0.6779	-0.6971	0.4793	1	
Quality Index	0.8582	0.8844	-0.7236	0.6089	0.8838	1

Annex 3E: Alternative Models

As a robustness check on the main results obtained from the model where individuals are matched on the basis of their firm and insurance institution choices, a number of models similar to the "matched applicant" models of Dale and Krueger (2002) are run. Dale and Krueger form groups of students who applied to a similar set of schools and received the same admission decisions (i.e. the same combination of acceptances and rejections). Because there were so many colleges to which students applied, they considered schools equivalent if their average SAT score fell into the same 25 point interval. For example, if two schools had an average SAT score between 1,200 and 1,225, the authors assumed they used the same admission cut-off. Then they formed groups of students who applied to, and were accepted and rejected by, "equivalent" schools.

The models run in this annex are similar to these "matched applicant" models, however "similar" institutions are defined slightly differently as institutions that are in the same quantile of selectivity. Models are run with 2, 4, 8, 16, 32 and 64 quantiles, respectively. In the simplest case, this means that institutions are divided into two groups (high v. low selectivity) and individuals matched based upon whether they applied and were accepted to institutions from the top/bottom half in terms of selectivity. There are 145 different institutions in my dataset, so in the most elaborate model, this means that there are 145/64 (i.e. around 2) institutions per selectivity grouping.

In addition, a model is run where individuals are matched on the exact institutions that they applied to and were accepted to.

As Table 3E-1 shows, these models suggest that a standard deviation increase in selectivity leads to an increase in earnings three and a half years after graduation of between 3.6% and 5.8% - findings very similar to the ones obtained in the main body of the text.

Table 3E-1: Results from the "Matched Applicant" Models

		(i)	(ii)	(iii)	(iv)
Model					
(i)	**2 Quantiles**	0.0801	0.0763	0.0628	0.0451
		(0.00873)***	(0.0116)***	(0.0107)***	(0.00761)***
	n	7741	7741	7741	7741
(ii)	**4 Quantiles**	0.0802	0.0709	0.0596	0.0403
		(0.00871)***	(0.00967)***	(0.00934)***	(0.00742)***
	n	7738	7738	7738	7738
(iii)	**8 Quantiles**	0.0809	0.0579	0.0485	0.0361
		(0.00896)***	(0.00890)***	(0.00869)***	(0.00761)***
	n	7326	7326	7326	7326
(iv)	**16 Quantiles**	0.0846	0.0646	0.0564	0.0443
		(0.00940)***	(0.0111)***	(0.0109)***	(0.00996)***
	n	5332	5332	5332	5332
(v)	**32 Quantiles**	0.0854	0.0749	0.0708	0.0518
		(0.0109)***	(0.0143)***	(0.0138)***	(0.0119)***
	n	3589	3589	3589	3589
(vi)	**64 Quantiles**	0.0796	0.0983	0.0942	0.0580
		(0.0168)***	(0.0251)***	(0.0251)***	(0.0247)*
	n	2159	2159	2159	2159
(vii)	**Exact Match**	0.0508	0.0816	0.0805	0.0414
		(0.0266)	(0.0278)**	(0.0287)**	(0.0249)
	n	1564	1564	1564	1564
	Firm/Insurance Group Fixed Effects	no	yes	yes	yes
	Tariff Score	no	no	yes	yes
	Additional Controls	no	no	no	yes

Standard errors in parentheses. These are clustered at the institutional level.

* p<0.05 ** p<0.01 *** p<0.001

Annex 4A: Year-on-Year Changes in Rank, by League Table

Figure 4A-1: Times Rankings – Year-on-Year Changes

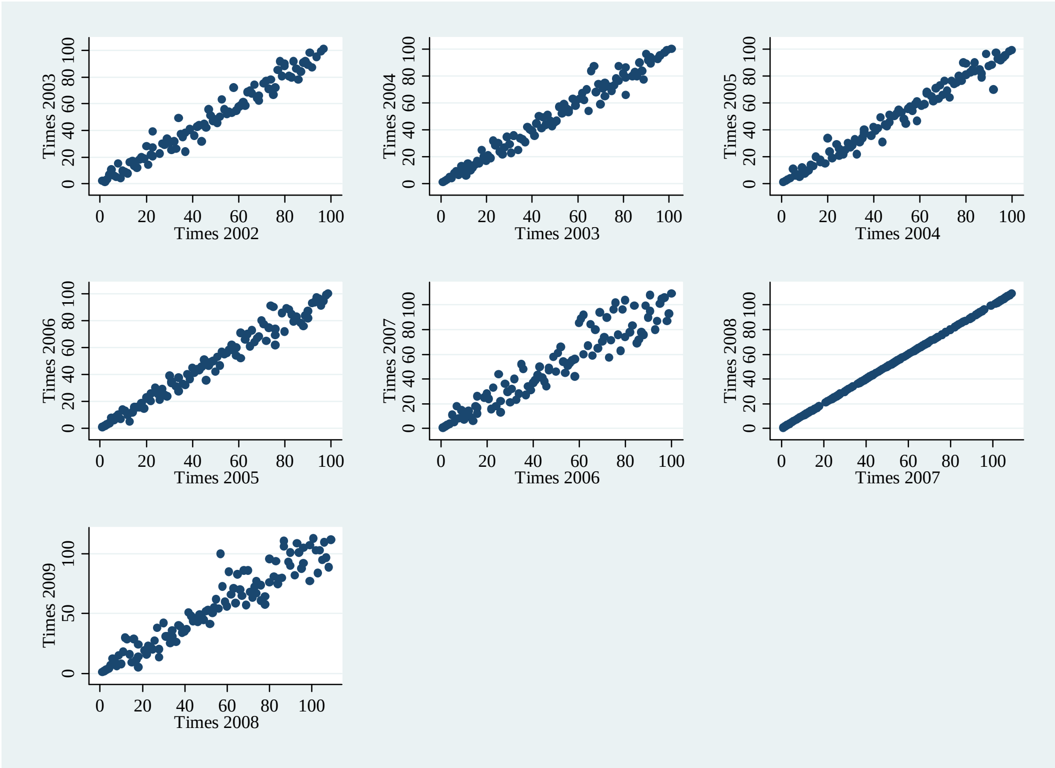

Table 4A-1: Times Rankings – Year-on-Year Correlation Matrix

	Times 2002	Times 2003	Times 2004	Times 2005	Times 2006	Times 2007	Times 2008	Times 2009
Times 2002	1							
Times 2003	0.9811	1						
Times 2004	0.9758	0.9834	1					
Times 2005	0.9614	0.9703	0.9864	1				
Times 2006	0.9615	0.9631	0.9805	0.9839	1			
Times 2007	0.931	0.9415	0.938	0.9452	0.9455	1		
Times 2008	0.931	0.9415	0.938	0.9452	0.9455	1	1	
Times 2009	0.9264	0.9424	0.9319	0.9307	0.9297	0.9577	0.9577	1

Explanatory note: there is no change between 2007 and 2008 in the Times rank as no Times league table was published in 2008. So the rankings for 2008 are assumed to be the same as in 2007.

Figure 4A-2: Guardian Rankings – Year-on-Year Changes

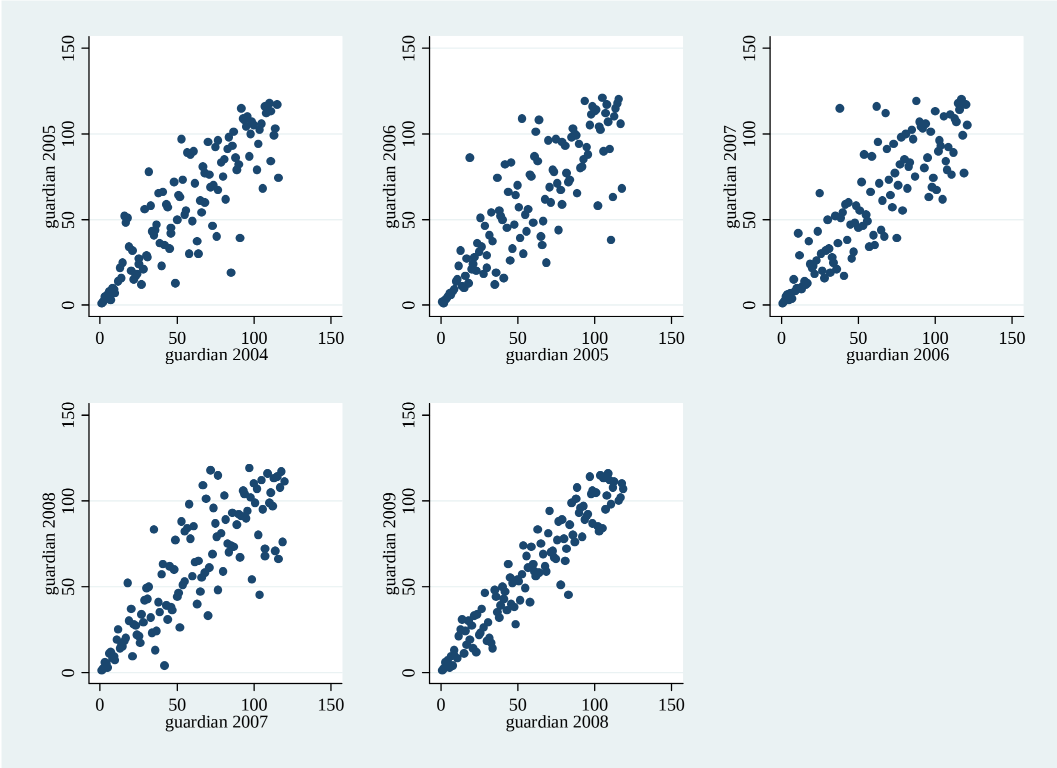

Table 4A-2: Guardian Rankings – Year-on-Year Correlation Matrix

	Guardian 2004	Guardian 2005	Guardian 2006	Guardian 2007	Guardian 2008	Guardian 2009
Guardian 2004	1					
Guardian 2005	0.851	1				
Guardian 2006	0.7875	0.8452	1			
Guardian 2007	0.874	0.8593	0.8884	1		
Guardian 2008	0.8417	0.7348	0.814	0.8532	1	
Guardian 2009	0.8435	0.7559	0.7866	0.8293	0.955	1

Figure 4A-3: THES Rankings – Year-on-Year Changes

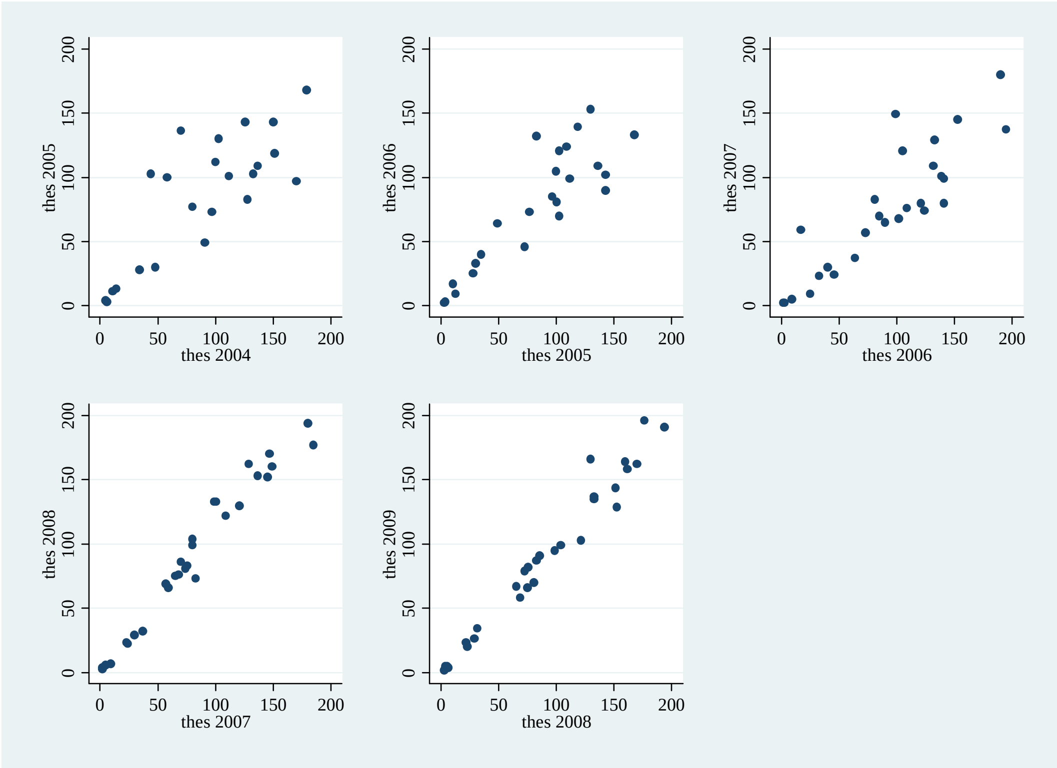

Table 4A-3: THES Rankings – Year-on-Year Correlation Matrix

	THES 2004	THES 2005	THES 2006	THES 2007	THES 2008	THES 2009
THES 2004	1					
THES 2005	0.8373	1				
THES 2006	0.8125	0.8852	1			
THES 2007	0.6115	0.7662	0.8625	1		
THES 2008	0.655	0.7806	0.8775	0.9849	1	
THES 2009	0.6025	0.7593	0.8341	0.9736	0.9816	1

Figure 4A-4: ARWU Rankings – Year-on-Year Changes

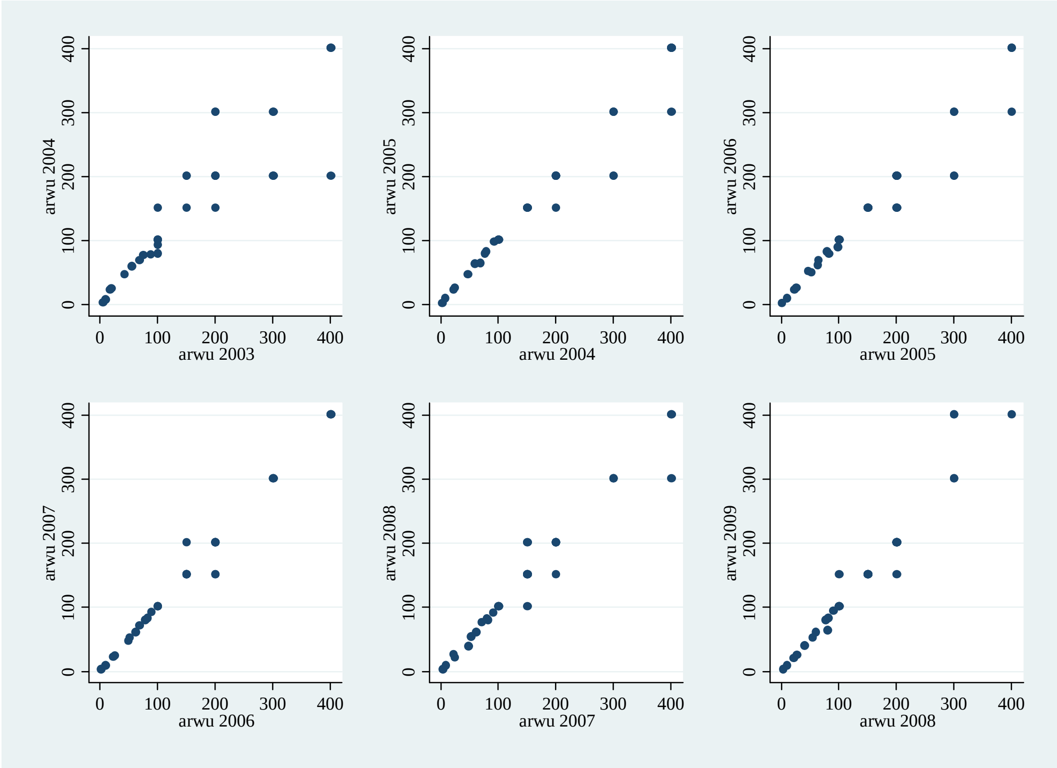

Table 4A-4: ARWU Rankings – Year-on-Year Correlation Matrix

	ARWU 2003	ARWU 2004	ARWU 2005	ARWU 2006	ARWU 2007	ARWU 2008	ARWU 2009
ARWU 2003	1						
ARWU 2004	0.879	1					
ARWU 2005	0.8818	0.971	1				
ARWU 2006	0.9148	0.9461	0.9557	1			
ARWU 2007	0.8607	0.9464	0.9544	0.9836	1		
ARWU 2008	0.8789	0.9545	0.955	0.952	0.9559	1	
ARWU 2009	0.8909	0.9573	0.957	0.9639	0.9679	0.9857	1

Annex 4B: Matching Rankings to Outcomes

The table below provides an example of how rankings are matched to outcome variables. As a reminder, it is assumed that applicants to university use the most recently published league tables. Most guides are published in late summer in time for the applications process (which starts in autumn) for enrolment in the following academic year. Similarly, for international student fees, it will be assumed that fees in any particular year are set based on the institution's ranking in the previous year.

Ranking	Year	Published	Influences applications for	Influences fees for
Times	2011	Summer 2010	September 2011	N/A
Guardian	2011	Summer 2010	September 2011	N/A
THES	2011	Summer 2010	September 2011	September 2011
ARWU	2010	Summer 2010	September 2011	September 2011

Taking an example from the table, the 2011 Times Good University Guide came out in late Summer 2010 and was meant to influence students who applied over the course of 2010/2011 for enrolment in the 2011/2012 academic year.

Annex 4C: Methodological Changes in the Guardian and Times Rankings

Explanatory note: changes on the previous year are marked in bold.

Guardian 2004		Guardian 2005	
Variable	Weighting	Variable	Weighting
Teaching Inspection	40%	Teaching Inspection	**22%**
Entry Qualifications	10%	Entry Qualifications (**New Method**)	**15%**
Spend per Student	10%	Spend per Student	**15%**
Student/Staff Ratio	10%	Student/Staff Ratio	**15%**
Value Added	15%	Value Added (**New Method**)	**10%**
Jobs Prospects	15%	Jobs Prospects (**New Method**)	15%
		Inclusiveness	**8%**

Guardian 2006		Guardian 2007	
Variable	Weighting	Variable	Weighting
Staff Score	**15%**	Staff Score	15%
Entry Qualifications	**20%**	Entry Qualifications	20%
Spend per Student	**10%**	Spend per Student	10%
Student/Staff Ratio	**20%**	Student/Staff Ratio	20%
Value Added	10%	Value Added	10%
Jobs Prospects	**17%**	Jobs Prospects	17%
Inclusiveness	8%	Inclusiveness	8%

Guardian 2008		Guardian 2009	
Variable	Weighting	Variable	Weighting
Teaching Quality	**10%**	Teaching Quality	10%
Entry Score	**17%**	Entry Score	17%
Spend per Student	**17%**	Spend per Student	17%
Student/Staff Ratio (**New Method**)	**17%**	Student/Staff Ratio	17%
Value Added (**New Method**)	**17%**	Value Added	17%
Jobs Prospects	17%	Jobs Prospects (**New Method**)	17%
Feedback	5%	Feedback	5%

Times 2002		Times 2003	
Variable	Weighting	Variable	Weighting
Teaching Assessment	2.5	Teaching Assessment	2.5
Research Assessment	1.5	Research Assessment (**New Data**)	1.5
Entry Standards	1.0	Entry Standards (**New Method**)	1.0
Student Staff Ratio	1.0	Student Staff Ratio	1.0
Library and Computer Spending	1.0	Library and Computer Spending	1.0
First and Upper Seconds	1.0	First and Upper Seconds (**New Method**)	1.0
Facilities Spending	1.0	Facilities Spending	1.0
Graduate Destinations	1.0	Graduate Destinations (**New Method**)	1.0
Efficiency	1.0	Efficiency	1.0

Times 2004		Times 2005	
Variable	Weighting	Variable	Weighting
Teaching Assessment	2.5	Teaching Assessment	2.5
Research Assessment	1.5	Research Assessment	1.5
Entry Standards	1.0	Entry Standards	1.0
Student Staff Ratio	1.0	Student Staff Ratio	1.0
Library and Computer Spending	1.0	Library and Computer Spending	1.0
First and Upper Seconds	1.0	First and Upper Seconds	1.0
Facilities Spending	1.0	Facilities Spending	1.0
Graduate Destinations	1.0	Graduate Destinations	1.0
Efficiency	1.0	Efficiency	1.0

Times 2006		Times 2007	
Variable	Weighting	Variable	Weighting
Teaching Assessment	2.5	Teaching Assessment	2.5
Research Assessment	1.5	Research Assessment	1.5
Entry Standards	1.0	Entry Standards	1.0
Student Staff Ratio	1.0	Student Staff Ratio	1.0
Library and Computer Spending	1.0	Library and Computer Spending	1.0
First and Upper Seconds	1.0	First and Upper Seconds	1.0
Facilities Spending	1.0	Facilities Spending	1.0
Graduate Destinations	1.0	Graduate Destinations	1.0
Efficiency	1.0	Efficiency	1.0
		Student Satisfaction	1.5

Times 2009	
Variable	Weighting
Teaching Assessment	2.5
Research Assessment	1.5
Entry Standards	1.0
Student Staff Ratio	1.0
First and Upper Seconds	1.0
Facilities Spending (**New Method**)	1.0
Graduate Destinations	1.0
Efficiency	1.0
Student Satisfaction	1.5

Annex 4D: Models with Institution-Specific Time Trends

Table 4D-1: Impact of a Drop in Rankings on Applications, Proportion of Applications Accepted and Average Tariff Score of (Accepted) Applicants – UK-Domiciled Students – Institution-Specific Time Trends

		(i)	(ii)	(iii)	(iv)
		Number of Applications	% of Applications Accepted	Average Tariff Score of Applicants	Average Tariff Score of Accepted Applicants
Times	β	-9.432	0.000277	-0.302	-0.341
	s.e.	(12.41)	(0.000298)	(0.0980)***	(0.109)***
	n	671	671	671	671
Guardian	β	-13.66	0.000247	-0.111	-0.148
	s.e.	(5.535)**	(0.000141)*	(0.0403)***	(0.0448)***
	n	565	565	565	565
THES	β	-10.74	0.0000204	0.00513	-0.0485
	s.e.	(10.19)	(0.000260)	(0.0879)	(0.0976)
	n	123	123	123	123
ARWU	β	-9.746	0.0000217	-0.0157	-0.00888
	s.e.	(7.171)	(0.000158)	(0.0369)	(0.0423)
	n	170	170	170	170
* 0.10 ** 0.05 *** 0.01					

Table 4D-2: Impact of a Drop in Rankings on Applications, Proportion of Applications Accepted and Average Tariff Score of (Accepted) Applicants – UK-Domiciled Students, Russell Group Institutions – Institution-Specific Time Trends

		(i)	(ii)	(iii)	(iv)
		Number of Applications	% of Applications Accepted	Average Tariff Score of Applicants	Average Tariff Score of Accepted Applicants
Times	β	-136.9	0.00209	-0.571	-0.501
	s.e.	(71.14)*	(0.00113)*	(0.383)	(0.360)
	n	126	126	126	126
Guardian	β	-60.15	-0.000189	0.311	0.312
	s.e.	(32.22)*	(0.000462)	(0.224)	(0.231)
	n	90	90	90	90
THES	β	-16.03	-0.0000629	0.0678	-0.0105
	s.e.	(15.43)	(0.000205)	(0.0878)	(0.0805)
	n	81	81	81	81
ARWU	β	-4.571	0.000234	-0.0000132	-0.0486
	s.e.	(7.285)	(0.000235)	(0.0794)	(0.0849)
	n	89	89	89	89
* 0.10 ** 0.05 *** 0.01					

Table 4D-3: Impact of a Drop in Rankings on the Number of Applications by Gender and Ethnicity – UK-Domiciled Students – Institution-Specific Time Trends

		Gender		Ethnicity			
		Male	Female	White	Black	Asian	Mixed
Times	β	-10.56	1.130	-7.574	4.712	-4.891	0.374
	s.e.	(5.914)*	(7.067)	(11.00)	(2.795)*	(1.441)***	(0.712)
	n	671	671	671	671	671	671
Guardian	β	-7.269	-6.392	-12.24	1.902	-1.755	0.0393
	s.e.	(2.610)***	(3.243)*	(4.696)**	(1.083)*	(0.695)**	(0.196)
	n	565	565	565	565	565	565
THES	β	-3.965	-6.774	-9.906	-0.619	0.260	-0.730
	s.e.	(4.432)	(6.207)	(8.257)	(0.689)	(1.062)	(0.470)
	n	123	123	123	123	123	123
ARWU	β	-3.507	-6.239	-8.505	-0.129	-0.332	-0.166
	s.e.	(3.265)	(4.225)	(5.707)	(0.755)	(0.880)	(0.295)
	n	170	170	170	170	170	170
* 0.10 ** 0.05 *** 0.01							

Table 4D-4: Impact of a Drop in Rankings on the Number of Applications by Age and Socio-Economic Class – UK-Domiciled Students – Institution-Specific Time Trends

		Age		SEC	
		Young	Mature	High	Low
Times	β	-14.61	5.173	-9.706	0.536
	s.e.	(10.88)	(3.658)	(6.825)	(3.336)
	n	671	671	671	671
Guardian	β	-15.15	1.488	-8.486	-3.868
	s.e.	(5.027)***	(1.707)	(3.119)***	(1.569)**
	n	565	565	565	565
THES	β	-10.17	-0.572	-8.246	-0.423
	s.e.	(9.205)	(1.942)	(6.698)	(2.524)
	n	123	123	123	123
ARWU	β	-9.790	0.0431	-7.361	-1.136
	s.e.	(6.616)	(1.454)	(4.656)	(1.735)
	n	170	170	170	170
* 0.10 ** 0.05 *** 0.01					

Table 4D-5: Impact of a Drop in Rankings on the Number of Applications by School Type and Prior Attainment – UK-Domiciled Students – Institution-Specific Time Trends

		School Type		Prior Attainment			
		State	Independent	Top	Top Middle	Bottom Middle	Bottom
Times	β	-14.27	-5.991	-16.16	-1.883	10.44	-1.823
	s.e.	(10.44)	(2.330)**	(4.451)***	(4.949)	(5.394)*	(4.767)
	n	462	462	671	671	671	671
Guardian	β	-11.42	-1.918	-3.653	-3.742	-4.300	-1.967
	s.e.	(5.242)**	(0.790)**	(1.497)**	(1.771)**	(2.431)*	(2.614)
	n	338	338	565	565	565	565
THES	β	1.681	2.856	0.0542	-3.644	-3.310	-3.839
	s.e.	(6.141)	(3.195)	(4.578)	(3.465)	(3.054)	(2.605)
	n	68	68	123	123	123	123
ARWU	β	-1.363	-2.088	-3.898	-5.343	-1.060	0.555
	s.e.	(5.554)	(2.352)	(3.137)	(2.771)*	(2.580)	(2.180)
	n	101	101	170	170	170	170

* 0.10 ** 0.05 *** 0.01

Table 4D-6: Impact of a Drop in Rankings on Applications, the Proportion of Applications Accepted, and Fees Charged – International Students – Institution-Specific Time Trends

		(i)	(ii)	(iii)	(iv)	(v)	(vi)
		Number of EU Applications	% of EU Applications Accepted	Number of Other Overseas Applications	% of Other Overseas Applications Accepted	Fees Classroom-Based Courses	Fees Laboratory-Based Courses
Times	β	-3.034	0.000590	-8.233	0.000579	-3.602	-5.318
	s.e.	(1.764)*	(0.000507)	(2.000)***	(0.000447)	(2.564)	(4.100)
	n	780	692	671	671	688	688
Guardian	β	-2.283	0.000139	-2.768	0.000417	-1.100	-1.968
	s.e.	(0.642)***	(0.000216)	(0.922)***	(0.000298)	(1.211)	(1.596)
	n	683	683	565	565	570	570
THES	β	-2.640	-0.000488	1.684	-0.000319	-2.922	-3.928
	s.e.	(1.337)*	(0.000256)*	(3.076)	(0.000253)	(2.168)	(2.628)
	n	160	160	123	123	130	130
ARWU	β	-0.229	0.000247	0.157	-0.000236	4.566	6.356
	s.e.	(1.268)	(0.000129)*	(1.322)	(0.000274)	(1.662)***	(1.881)***
	n	214	214	170	170	183	183

* 0.10 ** 0.05 *** 0.01

Annex 4E: Combined Impact of Times and Guardian Rankings

Table 4E-1: Impact of a Drop in the Combined Times and Guardian Ranking on Applications, Proportion of Applications Accepted and Average Tariff Score of (Accepted) Applicants – UK-Domiciled Students

		(i)	(ii)	(iii)	(iv)
		Number of Applications	% of Applications Accepted	Average Tariff Score of Applicants	Average Tariff Score of Accepted Applicants
(Times+Guardian)/2	β	-18.30	0.000231	-0.138	-0.162
	s.e.	(7.397)**	(0.000179)	(0.0486)***	(0.0514)***
	n	751	751	751	751
Times	β	-18.91	0.0000921	-0.135	-0.137
	s.e.	(8.740)**	(0.000240)	(0.0751)*	(0.0872)
Guardian	β	-5.901	0.0000821	-0.144	-0.183
	s.e.	(5.583)	(0.000132)	(0.0335)***	(0.0386)***
	n	485	485	485	485

* 0.10 ** 0.05 *** 0.01

Annex 4F: Impact of a Drop in Rankings on the Socio-Economic Make-Up of Applications to Universities

Table 4F-1: Impact of a Drop in Rankings on the Proportion of Applications from Female, Black, Mature, State School, Lower SEC and Lower Attaining Candidates – UK-Domiciled Students

		PROPORTION OF APPLICATIONS THAT ARE					
		Female	Black	Mature	State Schools	Low SEC	25% Lowest Attaining Students
Times	β	0.000325	0.000119	0.000351	-0.000180	0.0000465	-0.000373
	s.e.	(0.000119)***	(0.000108)	(0.000131)***	(0.000130)	(0.0000609)	(0.000244)
	n	671	671	671	462	671	671
	$\bar{X}$	0.54	0.05	0.15	0.58	0.26	0.26
Guardian	β	0.000163	0.000160	0.000212	-0.00000498	0.0000202	0.000176
	s.e.	(0.0000638)**	(0.0000532)***	(0.0000705)***	(0.0000757)	(0.0000336)	(0.000110)
	n	565	565	565	338	565	565
	$\bar{X}$	0.56	0.06	0.15	0.58	0.27	0.27
THES	β	-0.0000894	-0.00000887	-0.0000312	0.0000124	0.0000346	0.0000112
	s.e.	(0.0000624)	(0.0000237)	(0.0000524)	(0.0000695)	(0.0000483)	(0.0000870)
	n	123	123	123	68	123	123
	$\bar{X}$	0.52	0.04	0.10	0.61	0.19	0.13
ARWU	β	-0.0000828	-0.00000866	-0.0000223	0.0000625	0.0000170	0.0000849
	s.e.	(0.0000604)	(0.0000217)	(0.0000577)	(0.0000449)	(0.0000449)	(0.0000840)
	n	170	170	170	101	170	170
	$\bar{X}$	0.52	0.04	0.10	0.62	0.21	0.14

* 0.10 ** 0.05 *** 0.01

Annex 4G: The Impact of University Rankings in the US

Study	Institutions Looked At	Effect on:			
		Number of Applications	Admit Rate	SAT Score	Fees
Monks and Ehrenberg (1999)	Top, privately-controlled institutions		A fall of 5 positions in the rankings is associated with an increase in the admit rate of almost 2 percentage points.	An increase in rank of 5 positions is associated with an increase in average SAT score of 5.5 points.	A fall in the rankings of 20 places results in a 3% reduction of net tuition.
Meredith (2004)	All schools classified as national doctoral universities		A school improving its ranking from the second to the first quartile increases its acceptance rate by about 1.0%. Dropping one rank between 26 and 50 equates to a 0.156% decrease in the acceptance rate.	As a public school's ranking drops from quartile one to quartile two, SAT scores decline by almost 20 points. SAT scores at private schools increase 13 points (but this is statistically insignificant).	
Bowman and Bastedo (2009)	Top-tier institutions	Moving into the top 50 results in a 3.9% increase in the overall number of applications. Moving up one place in the top 25 increases the number of applications by 0.95%. Moving up one place outside the top 25 has no significant effect.	Moving into the top 50 results in a 3.6% decrease in acceptance rate. Moving up one place in the top 25 decreases the acceptance rate by 0.25%. Moving up one place outside the top 25 has no significant effect.	No significant effect of moving into the top 50. Moving up one place within the top 25 increases SAT scores by 1.4 points. Moving up one place outside the top 25 increases average SAT scores by 1.4 points.	

Annex 4H: The Impact of Fees on the Relationship between University Rankings and Applications to University

Fees in English universities are set to rise to a maximum of £9,000 from 2012/13 onwards. It is possible that this increase in the cost of a university education will lead applicants to pay more attention to league table information as they try to make the most informed choice possible about which institution to attend.

It is not, of course, the first time the fee cap has been raised in England. In 2006/07 significant changes to the student finance system were introduced in the various regions of the UK, including a raising of the fee cap in England, Wales and Northern Ireland from £1,000 to £3,000.

It is important to stress, however, that although there was an increase in tuition fees paid by students in 2006/07, these were no longer payable upfront and most students were entitled to a loan to cover all of their fees. In fact, Dearden, Fitzsimons and Wyness (2011) conclude that the net result of the reforms was actually a reduction in the net upfront costs of going to university for students from all income groups. This would make the 2006/07 reforms a poor precedent to analyse what might happen when the cost of university increases from 2012/13 onwards.

Bearing the above caveat in mind, the table below summarises the results from regressions of the number of UK-domiciled applications on: (i) a university's ranking (Times or Guardian); (ii) a dummy variable set to one post-2006/07 (called "Fee"); (iii) regional dummies (Scotland, Wales, Ireland, with England omitted); and (iv) interactions of all of these. Because the number of choices that candidates were allowed to express was reduced from six to five in 2008/09, the sample was restricted to all years prior to 2008/09.

The variable of interest is the interaction of "Fee" and "Ranking" – indicating whether the effect of rankings changed in England after the fee cap was raised in 2006/07. Further interactions of the "Fee" dummy with "Ranking" and the regional dummies capture how the change in effect might have varied across Scotland, Ireland and Wales.

The results offer no evidence to suggest that rankings became more important to applicants in any of the regions following the raising of the fee cap in 2006/07. If anything, the data suggest that they may have become less important. Although seemingly counter-intuitive, this finding would actually be consistent with the conclusion of Dearden, Fitzsimons and Wyness (2011) that the net result of the 2006/07 reforms was a reduction in the net upfront costs of going to university.

Table 4H-1: The Impact of Fees on the Relationship between University Rankings and Applications to University

Ranking:	Times	Times	Times	Guardian	Guardian
Years:	2002-2009	2002-2007	2004-2007	2004-2009	2004-2007
Ranking	-69.96	-69.96	-64.98	-110.8	-110.8
	(16.89)***	(16.87)***	(23.87)***	(19.10)***	(19.14)***
Scotland	-2337.5	-2337.5	-1722.1	-2542.3	-2542.3
	(2582.5)	(2579.3)	(3712.6)	(3938.4)	(3947.6)
Wales	2198.0	2198.0	4354.2	1262.8	1262.8
	(4861.5)	(4855.6)	(6810.8)	(5899.0)	(5912.9)
Ireland	-14386.3	-14386.3	-19715.4	-21292.4	-21292.4
	(9691.0)	(9679.1)	(16897.4)	(25462.0)	(25522.0)
Fee	-1037.3	-778.8	-986.3	-1925.6	-1869.3
	(1369.5)	(1685.3)	(1996.0)	(1572.2)	(1818.0)
Ranking*Fee	27.67	22.97	17.99	48.55	42.29
	(22.15)	(27.17)	(32.32)	(23.09)**	(26.44)
Scotland*Ranking	-68.37	-68.37	-84.21	-12.90	-12.90
	(48.65)	(48.59)	(68.42)	(58.02)	(58.16)
Wales*Ranking	-178.0	-178.0	-223.9	-75.16	-75.16
	(82.41)**	(82.31)**	(117.0)*	(68.20)	(68.36)
Ireland*Ranking	492.4	492.4	602.4	613.4	613.4
	(221.7)**	(221.4)**	(370.9)	(520.0)	(521.2)
Scotland*Fee	3548.6	4133.7	3518.3	1998.1	3016.1
	(3648.8)	(4473.0)	(5268.6)	(4683.4)	(5585.7)
Wales*Fee	3673.4	6026.7	3870.4	2769.4	618.2
	(6580.3)	(7977.5)	(9397.3)	(7026.4)	(7719.3)
Ireland*Fee	-3907.8	-4832.1	497.0	9041.4	11045.7
	(15550.7)	(19444.4)	(24147.7)	(27234.7)	(28190.7)
Scotland*Fee*Ranking	-72.86	-82.90	-67.05	-81.16	-69.69
	(67.59)	(84.15)	(98.09)	(73.57)	(86.59)
Wales*Fee*Ranking	-50.04	-94.76	-48.90	-57.04	-20.14
	(110.8)	(136.9)	(161.9)	(81.61)	(88.97)
Ireland*Fee*Ranking	76.79	135.0	25.01	-228.0	-229.4
	(357.4)	(445.0)	(541.7)	(552.8)	(568.8)
Constant	20892.7	20892.7	21100.1	22073.2	22073.2
	(997.0)***	(995.7)***	(1431.7)***	(1279.5)***	(1282.5)***
n	780	567	387	683	456