The Best Things in Life are Free, But Some Students Need Bursaries: Financial Aid and College Outcomes

PRELIMINARY AND INCOMPLETE, PLEASE DO NOT CITE

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Abstract: Billions of pounds per year is spent on aid for poor students in HE systems around the world, yet there remains limited evidence on the causal effect of these payments, particularly on the intensive margin. This is an empirical challenge since student aid is correlated with characteristics which influence both college enrolment and achievement. We overcome these challenges by studying a unique form of non-linear means tested financial aid which is unadvertised, varies substantially across institutions, and is subject to shifts in generosity across cohorts.. Using student-level administrative data collected from 10 English universities, we study the effects of aid receipt on college completion rates, annual course scores, and degree class. Our findings suggest that each £1,000 of financial aid awarded increases the chances of gaining a good degree by 6.9 percentage points, driven by completion of the concurrent year and course scores. Whilst our results indicate that the impact of financial aid decreases as parental income rises, we find no differences in the gains by the enrollment test scores of the student.

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1. Introduction

Student aid is widely used around the world as a tool to promote access to university and to support disadvantaged students through their studies. England is no exception, where spending on student aid, in the form of government grants, subsidies on maintenance loans and university based financial aid reaches billions of pounds annually.[1]

To date, the majority of student aid research has focused on its effects on university enrolment, specifically focusing on participation decisions (see Kane 1999, Dynarski, 2003; 2003, Seftor and Turner 2002, Nielsen et al., 2010). However, there is surprisingly little research estimating the causal effect of aid on student outcomes whilst in college (degree completion, annual course scores and final degree classification). This set of outcomes is particularly important since aid-eligible students may be more likely to drop out of college or perform poorly in exams (Bettinger, 2004).

Yet, as is widely acknowledged in the literature (Dynarski, 2003) estimating the impact of student aid on educational attainment is an empirical challenge. There are three main issues at play. First, student aid tends to be correlated with many observable and unobservable factors that also affect an individuals' educational attainment. Aid recipients are more likely to be from poor backgrounds – and poor students are also more likely to drop out of college or fail exams for reasons unrelated to receipt of aid. A second problem is that aid is often related to student ability, either through the institution attended (since more able students congregate at better universities, who may in turn provide more generous financial packages), or directly through merit based aid programmes. Finally, the prospect of aid receipt at a university may be

[1] In 2009/10, the UK government spend on was £1050m on maintenance grants, £722m on student fee loan subsidies and £610m on maintenance loan subsidies. Universities themselves spent £300m on bursaries. Sources: Student grant figures – Student Loans Company, Statistical First Release, 06/2009, Table 3. Maintenance loan and fee loan figures – DIUS Annual Report 2009, annex 1, Table 11. (This does not represent the amount of money lent to students, but the future cost of subsidising and writing off student loans issued in that year as well as management of the student loans stock).

correlated with a students' likeliness to attend that particular college, making it difficult to separate the effects of aid receipt from enrolment effects.

In this paper we study a particular form of student aid – the English higher education bursary scheme – which we argue has unique features which help to overcome these problems, and establish the causal impact of this element of financial aid on student performance at university.

The English bursary scheme is different to other bursary schemes around the world, such as that in place in the US. The scheme is large-scale - around 44% of students receive a bursary, and over £300m is spent on bursaries every year[2] - meaning that the amount received by students is actually relatively small, averaging around £860 per bursary holder per year. This money is used for living expenses rather than as partial payment of tuition fees, which are deferred and do not require repayment until the student has graduated and is earning over £21,000 per year.

Bursaries were initially brought in in 2006, to allay fears that a significant increase in tuition fees (from £1,200 per year to £3,000 per year) would deter students from low income backgrounds from entering post-secondary education. The regulations on bursaries state that they are not to be merit based (scholarships), but to be solely determined by parental income. Moreover, it was mandated that universities spend a minimum of 10% of tuition fee income on bursaries.

However, universities were provided with no guidance or research with how to allocate these funds. Rather, they were given complete independence in how much they gave out and to whom. The upshot is universities designed their schemes on a somewhat arbitrary basis, and there is substantial variation in bursary generosity across institutions, with bursary amounts in

[2] See OFFA (2015): Table 1e. Note that published figures do not provide a split of spending on bursaries and scholarships separately but it is widely known the bursary spending constitutes the vast majority of this spending.

our sample varying between £300 and £4,000 per year. Moreover, there is a large degree of cross-cohort variation within institution over time as universities experimented with their schemes from year to year.

This set up effectively solves the first of our key problems. Whilst poor students are more likely to receive financial aid under the English bursary scheme, the definition of a poor student, and how much they receive in bursary, varies across institution and within institution over time. In other words, whilst typically there would be no observable counterfactual to a poor student receiving aid (since all poor students receive aid), our data contain a range of counterfactuals at different levels of parental income. This is best illustrated by Figure 1. This shows average bursary paid over deciles of the parental income distribution of students that received bursary aid. Within each household income bracket, each point on the chart represents a university. As is evident, for students of similar income backgrounds, there is a substantial range of bursaries on offer. For example, students with parental incomes of less than £10,000 per year could receive as little as £350 and as much as £2,800 per year depending on the university attended.

A second concern is that aid can be related to student ability – itself driver of student outcomes – because high ability students attend certain institutions which may also offer higher bursaries. Our set up alleviates this issue by exploiting changes in the bursary schemes within universities over time. By way of example, Figure 2 shows how the bursary scheme of a single university changed between 2006 and 2011. During this time the maximum bursary that could be received increased from £3000 and then subsequently decreased to £1000, while the maximum parental income of eligible students increased from £15,000 to £25,000. Moreover the number of different levels of bursaries awarded and at this university decreased from three

to two.[3] Thereby including university fixed effects along with controls for subject studied and enrolment test scores, we are ostensibly accounting for student ability and using the variation within a university across cohorts.

In our most preferred specification we exploit the sharp changes in bursaries awarded for a small change in parental income within a university cohort. Again see Figure 2, which highlights the discontinuities in bursary aid awarded within universities according to parental income. In this specification we include university-cohort fixed effects, whilst also accounting for up to a quadratic in parental income, entry test scores, a set of student characteristics and subject area studied. Here, the impact of aid is identified through imposing a smooth relationship of outcomes with parental income coinciding with sharp changes in aid awarded.

A related issue concerns merit-based aid. Typically in other bursary schemes around the world, aid is more commonly awarded to students with higher entry test scores. Hence, we again might be concerned that students with high prior attainment also receive high amounts of aid. In this case our estimates of the effect of aid on student performance would be biased upwards. However the English scheme is non-merit based. So, conditional on parental income, bursary receipt is orthogonal to entry test scores. Moreover, as Figure 3 shows, whilst universities vary in quality, there is substantial overlap in entry test score requirements. This is driven by universities having different entry requirements for different subjects, particularly arising when a university has a strong reputation in a particular subject area. Hence, there is a high incidence of common support in test scores across institutions.

As well as helping us to estimate the impact of bursaries on student performance, the availability of these counterfactuals – for household income and entry test scores – gives us the

[3] In practise, for the majority of institutions, students are subject to the bursary rules in place upon year of entry to the course, so that policy change occurring during the duration of their course do not affect them, only new entry students. However, for some institutions, policy rule changes affect all students regardless of entry year.

added advantage that we can study variation in bursary effectiveness by household income and student ability (as measured by entry test scores) – something hitherto unavailable in the literature. This is particularly useful, since a common argument (Guryan, 2004) is that providing aid to marginal students may be inefficient since such students may lack the skills necessary to benefit from college, particularly in the labour market. These institutional features allow us to estimate the impact of financial aid on both marginal and non-marginal students.

Our estimates could still be biased if students select their institution based on its financial aid package, either in general, or knowing that they will eligible for certain amount of aid – the third of our identification problems. For example, students from poor backgrounds might choose a particular institution if doing so would mean they gain from a particularly generous aid package, and may also be more likely to graduate for unobservable reasons unrelated to the generosity of aid e.g. motivation. This would create an upward bias in our estimates. However, in our setting, students are unlikely to sort on parental income, conditional on entry test scores, because students have very little possibility of knowing what their bursary is likely to be ahead of enrolling in college. This arises in part because university bursary schemes are highly opaque, and in part because of the rather convoluted university application scheme in place in England.

To explain in more depth, each university has its own unique bursary scheme in place. Bursary schemes are governed by complex means-testing rules, usually involving income thresholds and corresponding bursary amounts. Despite the generosity of such schemes they are rarely advertised in university prospectuses or included in aggregated university guides.[4] So, to understand what bursary they are entitled to, a student would have to navigate the finance

[4] To remedy this situation, Murphy and Wyness have recently collated the complete set of financial bursary rules for English universities and hosted a simplified version on the Guardian newspaper website for perspective students' use. This is available at http://www.theguardian.com/education/2015/jun/10/which-universities-offer-the-best-bursaries

pages of each institution they are interested in, understand the bursary schedule in place, and calculate their corresponding entitlement. Evidence that English bursaries do not influence enrolment choices of students has been provided by Corver (2009) who looks at the impact of bursaries on application to university using detailed administrative data. His study found no link between the amount of bursary on offer and likeliness to enrol in that particular university.

In addition to the lack of information, there is a large uncertainty at the time of application about which university they will eventually attend – and hence, which bursary they are going to receive. Students apply to university through the UCAS (Universities and Colleges Admissions Service) around nine months in advance. In the first stage of the application process, students make applications to up to 7 universities, with their application comprising of a personal statement and their predicted entry scores (generally A-level[5] grades). They then receive offers from each of the universities they have applied to, in each case conditional on entry scores. At this point, the student must rank these offers in order of preference. Finally, once the student has received their entry scores, they are obliged to attend the highest ranked university for which they meet the entry score criteria. The upshot of all of this is that i) students cannot know ahead of time what bursary they will end up with, since they do not know which university they will end up attending until they receive their final grades, ii) controlling the amount of bursary received by gaming the system (e.g. by mis-reporting parental income) would be near impossible since parental income thresholds vary by university, so students would not know which threshold to game. Thus, the institution students attend is likely to be unrelated to their financial aid package, and is more likely to be driven by idiosyncratic preferences, conditional on entry scores.

[5] Entry requirements vary by institution but generally students are required to have a minimum of 2–3 A-levels (the academic qualification offered by educational institutions to students completing secondary or pre-university education)

To examine the impact of bursary aid on college completion and degree performance we make use of a unique dataset collected from 10 higher education institutions in England. The dataset comprises individual-level data on UK and EU undergraduate students (i.e. those eligible for bursaries), comprising the institution and course attended, the bursary they are awarded each year (including zeros), their parental income and their college entry test scores, as well as basic demographics and background characteristics. These data also hold detailed information on their university performance, comprising their annual course scores, number of years of university completed, and their final degree classification. Such detailed data is largely unavailable in standard datasets.

We use the variation in financial aid for a given level of entry test scores and parental income to estimate its effect on student outcomes. This exploits variation in the generosity of the schemes both across universities and within universities over time. Additionally we use variation within a university cohort by exploiting the large non-linear changes in bursaries awarded for a small linear changes in parental income using a set of university by cohort fixed effects.

Our fixed effects regressions suggest that each £1,000 of financial aid awarded increases the chances of obtaining a good degree by 6.9 percentage points. This is driven by both degree completion and higher course scores in the concurrent year. For example, we find that at the mean each £1,000 of financial aid awarded in the first year increases the chances of completing that year by 7.4 percentage points (a figure comparable to that found by Bettinger, 2004) and increases test scores by 0.11 standard deviations. We find similar results in subsequent years.

The heterogeneity in support allows us to make inferences about an optimal financial aid package for students from different parental income backgrounds – something rarely available in previous research. For the average student, the impact of bursaries increases in the amount awarded up to a bursary amount of £2,300 per year. This falls to £1,000 for those in the highest

parental income decile of bursary receivers. This is compatible with the finding that the marginal impact of financial aid is strictly decreasing in parental income, implying that financial aid is most effective for low income students, and that bursaries may be acting to relieve liquidity constraints.

We can also look at the impact of aid for students of different types of ability. There is a concern in the literature (Bettinger, 2004; Guryan, 2004) that the targeting of aid to low income students simply subsidises marginal students, who are least likely to gain from a degree, by keeping them in college. If this were true, one would find the impact of aid decreasing in entry test scores. Alternatively, if high ability students gained the most from bursaries, we would expect to find the impact of aid increasing in test scores. In fact, we find that the effect of additional aid is unrelated to prior test scores, implying that aid is equally effective amongst low income students, regardless of ability. Finally we aim to use our findings to propose optimal bursary schemes for universities with different distributions of students, according to parental income.

The remainder of this paper proceeds as follows. Section 2 reviews the literature relevant to this paper, while Section 3 outlines the features of the UK student aid system. Section 4 describes our dataset. Section 5 goes on to outline the fixed effects methodology that will be employed, whilst Section 6 presents results. Section 7 presents robustness checks and Section 8 concludes.

2. Literature Review

The majority of the research on the effects of financial aid are based in the US and focus on their impact on enrolment. In general, these studies have found a positive impact of easy to apply for aid programmes on enrolment. Dynarski (2000) finds that Georgia's HOPE Scholarship, a merit-aid programme, had a positive impact on students: a $1,000 increase in

aid resulted in a 4 percentage point increase in HE participation. In a later paper (Dynarski, 2003) exploits a one-off policy change whereby financial aid was withdrawn from children with a deceased, disabled or retired father, finding that the reform reduced HE participation by 3.6 percentage points. Conversely, Kane (1995) looks at the impact of the Pell Grant aid system, finding no impact on participation, while Seftor and Turner (2002) find a small impact of Pell Grant eligibility of 0.7 percentage points per $1,000 of aid (although on a restricted sample of mature students).

Studies from the UK and Europe are rarer, possibly due to the paucity of 'clean' policy breaks and lack of large-scale data. Nielsen et al. (2010) exploit a change in aid in the Danish HE system which particularly benefitted higher income students, and find that a $1,000 increase in grants results in a 1.35 percentage point increase in HE participation. In the UK, Dearden et al (2014) study the impact of a policy reform which re-introduced grant aid to students from poor families in England, and find an impact on participation of 3.95 percentage points per £1,000.

A small number of papers from the US look at the impact of aid on both college enrolment and college completion or years of study. Turner and Bound (2002) focus on the impact of the G.I. Bill (which provided veterans of the Second World War funds for college education) on both college enrolment and completion, finding positive effects. Similarly Dynarski's 2003 paper examining the impact of the withdrawal of social security benefits, finds an effect on college completion of about 0.16 years per $1,000. Sjoquist and Winters (2012) examine the effects of state based merit-based aid programs on college attendance and completion, but find no evidence of a positive effect.

Closer in nature to our paper are those studies which look purely at college attainment (conditional on entry). There are a number of quasi-experimental papers which generally find financial aid to have negative impact on college drop-out and retention, and a positive impact

on completion. These include Bound et al., 2007; Dynarski, 2003; Bettinger, 2004. Also relevant are studies by Goodman (2008), Oreopoulos et al. (2009), Scott-Clayton (2011), DesJardins and McCall (2010), Garibaldi et al. (2012), and Joensen (2013) who demonstrate the potential effectiveness of providing incentives related to merit and timing in financial aid packages.

3. Institutional setup

The UK higher education system is characterised by high tuition fees (in 2012 they increased from £3,300 to £9,000[6] per year, meaning they are now the highest in Europe and on a par with many US institutions[7]) but a generous national system of financial support. This consists of means-tested fee and maintenance loans (the latter of up to £5,740 per year in 2015[8]), both repayable after graduation once the graduate is in employment and earning above £21,000 per year, and non-repayable means-tested maintenance grants of up to £3,387 per year for students with parental incomes less than £25,000.

However, maintenance grants will be abolished from September 2016 (with maintenance loans increased to make up the difference[9]), meaning higher education bursaries – the form of aid studied in this paper – will become the sole non-repayable form of student financial aid.[10] Bursaries also represent the sole form of aid which is governed at an

[6] All figures expressed in this section are in nominal prices

[7] Whilst tuition fees are decided at the institution level, in practise the vast majority of universities charge the full £9000 per year, and the average fee stood at £8,830 in 2015 (See OFFA (2015): Table 2)

[8] For full-time undergraduates living away from home and studying at English universities outside London. Different rates apply for those living at home or studying in London. See https://www.gov.uk/student-finance/loans-and-grants for full details.

[9] See http://www.ifs.org.uk/publications/7905 for more details

[10] There are other forms of non-repayable aid – mainly merit based scholarships and hardship funds, but these are generally restricted to a small number of students per institution; to the author's knowledge, no published data exist on the total value of these

institutional rather than a national level, giving rise to significant variation in eligibility across institutions, unlike the other national forms of aid.

As described in the introduction, the system of higher education bursaries was introduced by the UK government in 2006. This coincided with the replacement of upfront means-tested tuition fees of £1,200 per year with a deferred tuition fee of up to £3,000 per year[11] backed by a tuition fee loan. As part of these changes English institutions were required to offer a bursary to all disadvantaged students (defined as those in receipt of a full maintenance grant, £2,700 at that time; note there are no other requirements, such as prior academic attainment or academic performance whilst at university, though the student has to be registered each year to receive their bursary). The minimum bursary that institutions could offer was set to be the difference between full fee charged and the maintenance grant received by the student. Thus, the minimum bursary at the time was £300 per year (£3,000 in fees minus £2,700 grants). From 2010 onwards, the rules were redefined so that the minimum bursary became 10% of fee charged. Since fees at the time were around £3,200 per year, the minimum bursary remained around £320 per year.[12] In practise, the bursary offered across institutions has varied considerably.

A notable feature of the bursaries system concerns their delivery. Although each individual institution designs its own bursary scheme (including the income thresholds for bursary receipt and the amount of bursary on offer), the Student Loans Company (SLC)

[11] Again the tuition fee was intended to be decided at institution level but in practise, all institutions charged £3,000 per year

[12] Since 2012, no minimum bursary requirement has been in place. The bursary system was supplanted by the National Scholarship Programme (NSP) in which universities were allocated a set amount of money to distribute among their disadvantaged students in the form of bursaries, fee waivers or other benefits. The NSP has since been disbanded.

administers the bursary payment for the majority of schemes.[13] The procedure for the first year of entry and every subsequent year a student attends university is as follows:[14]

i. Upon application to university (and each subsequent year) students complete a student finance form in order to apply for the national system of tuition fee loans, maintenance loans and maintenance grants. The latter two elements of the system are means tested, thus students must divulge their parental income. They also have to consent for this information to be shared with their institution (of which 98% do).

ii. The SLC then verify the students' parental income with the help of HMRC (the department of the UK Government responsible for the collection of taxes, the payment of some forms of state support, and the administration of other regulatory regimes including the national minimum wage).

iii. The university supplies the SLC with the bursary eligibility rules it has chosen for that year. The SLC thus calculate bursary due to every student based on their parental income.

iv. The SLC inform the university of which students will receive a bursary and how much they should be paid. The university then has to decide whether to approve, modify or cancel a student's bursary. The vast majority of bursaries are approved (some 98%). Students who do not take up their place, or who drop out of study before the bursary payment is due will not be approved for payment. Occasionally, modifications are made, such as if a student switches institutions, or their income changes.

v. Prior to their arrival at university that year, the SLC send every eligible student a letter which appears to be from the university informing them that they are eligible for a bursary, and the amount they are eligible for.

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[13] Universities can opt to administer their own scheme but the majority choose to do so through the SLC

[14] The information that follows was provided to the author by the Student Loans Company in conversation – therefore no citations are available

vi. Finally, the SLC makes the payment to the student – at the same time the SLC debits the money from the institution's bank account.

A number of pertinent issues arise from this process. First, note that students do not have to apply for bursaries in order to receive them. Thus, there is no possibility of a student choosing not to take up their bursary (or forgetting to do so). As long as the student has applied for other forms of student support through the SLC (which include the £9,000 annual fee loan)[15] and choose to declare their parents' income, and are eligible for a bursary, they will receive it. The implication is that we will not have an issue with non-compliance, and our parameters do not represent intention to treat, as is common in financial aid literature (Dynarski, 2008, Dearden et al, 2012), but actually represent the impact of bursary aid receipt on outcomes.

A further important implication is that take-up of bursary each year is not endogenously related to eligibility in the previous year. For example, it may be the case that students who receive large bursaries in first year (and who may also be more likely to be low income) may be more likely to take up their bursaries the next year (and vice versa). As take-up is not governed by the students' wishes, our results do not suffer from this bias. Second, there is very little possibility of non-compliance on the part of the university, since they have minimal involvement in the administration of the bursary payment system, beyond designing the rules. A third outcome of this system is that if the student is not eligible for a bursary, the SLC discards their parental income data before returning the information to the university. Since the data in our sample is collected from universities, this means that we only hold parental income data for bursary holders.

[15] In 2011, 88% of eligible students took up maintenance loans (see www.parliament.uk/briefing-papers/sn01079.pfd)

4. Data

This paper makes use of a unique administrative dataset collected from 10 UK universities. The data comprise the entire undergraduate population of UK and EU students for up to 6 cohorts of students beginning their studies between 2006 and 2011.

We begin with a sample of 325,418 students. As our estimation strategy relies on using the variation in financial aid for a given level of entry test scores to estimate the effect of bursaries on student outcomes, we first discard those students for whom we have no knowledge of parental income. As stated in Section 3, we only hold parental income information for students who received a bursary at some point. This means our sample consists only of bursary holders.

This reduces our sample substantially, to 63,719 students. We then discard those of non-traditional age, retaining only students aged 21 or below upon starting university. We also discard those students undertaking vocational courses or those above or below degree level. This leaves 34,026 students in the sample. Our sample is truncated, meaning we observe some students all the way through their studies (typically 3 years), whilst we can only observe the first or second year of some students, since they would not have had the chance to complete their degrees at the time we obtained the data. Thus, in our preferred specifications, we use only the non-truncated sample of students, for whom we are able to observe their full transition through college, including dropouts. This is a total of 23,093 students. In a robustness check, looking only at completion in years 1 and 2, we include students for whom we only observe part of their transition through college – i.e. the full sample of 34,026 students.

University and course data

In each case our data contains information on the university attended (though for the purposes of this study, this is anonymised) and the subject studied. In the latter case data on some 2,200

courses was initially received. In the interests of simplicity, this was reduced to 22 different course types based on the widely-used JACS classifications See Appendix A).

Bursary/finance data

As described above, bursaries are administered through the Student Loans Company, then details of the bursaries paid out are returned to the university. The result is that the dataset contains full information on the bursary each student received each year, but parental income data only for those students in receipt of a bursary (since the Student Loans Company only returns data on those who were deemed eligible for a bursary).

Because university bursary eligibility rules are published online[16] it is possible to check whether the bursary received corresponds to the published university rules – i.e. where parental income is available, does the bursary received by the student correspond with that described in the OFFA guidelines, given the parental income of the student? Reassuringly, we find non-compliance levels of just 1.05-2.7% among those with parental income data, depending on the year in question.

Background information

The dataset holds information on the student background characteristics, such as their parental occupation, parental socio-economic status, their age at the point of entry, ethnic group, gender, disability status. Crucially, the dataset also contains information on the students' entry qualifications, in terms of their qualification types, subjects and grades. Again there were many hundreds of qualification types among the dataset. For simplicity we have therefore augmented the dataset with the corresponding UCAS (University and College Admissions Service) points

[16] These are available from OFFA access agreements, which are published annually by institution, available at: http://www.offa.org.uk/access-agreements/

assigned to this particular qualification. UCAS points scoring is the system used for students to meet the entry requirements for university admissions. All UK qualifications are awarded UCAS points, with the most common being A-Levels taken at the end of secondary school, which has a maximum points value of 140. Universities typically have entry requirements based on the best three A-Level equivalent scores. We calculated this corresponding score for each student.

Outcomes

The dataset tracks students throughout the course of their degree. Therefore we have information on each students final outcome, including whether they dropped out, and their year of drop out, their annual course scores (generally this was provided as an annual average of all courses taken rather than individual scores per course. Since these scores are not comparable across universities, or individuals – since students take different courses – we standardize these to have a mean of zero and a standard deviation of 1), and their final degree classification.

In Table 1 we present some descriptive statistics on the individuals in our sample. The average bursary per bursary holder is £712[17], though there is variation over year of study. 43% of the sample are male, whilst the average age is 18.6 and 79.9% are white. According to the most recent Higher Education Statistics Agency (HESA) statistics (HESA, 2015: Table 6a), 45% of full-time undergraduates are male, 61% are under 22, and 60% are white. Therefore, our sample is representative in terms of gender, but is younger and whiter than the UK undergraduate population, which is expected given our sample restrictions. Students receive on average £1,800 per year in non-repayable grant aid from the government. This implies the average bursary received among our sample of students is substantial, representing an additional 40% on grant aid.

[17] All prices are henceforth expressed in 2013 prices (RPI)

The university completion rate is almost 87% meaning that only 13% of students fail to complete university. This is compatible with the dropout rate from UK official statistics, of around 8% (HEFCE, 2014) bearing in mind our stricter (of traditional age, degree students) and poorer (bursary holder) sample. Drop out is highest in first year, at over 7%, and steadily declines. 62.6% of the entire sample obtain a good degree, defined here as a first or upper second class degree. Of those who complete their studies without dropping out, 72% obtain a good degree.

5. Estimation strategy

Estimating the impact of financial aid on student outcomes is typically fraught with issues due to the amount of aid received being highly correlated with factors that also impact on outcomes e.g. parental income and student ability. The institutional setting of the English bursary schemes allows for us to disentangle these effects. We use three progressively more specific sources of variation in financial aid awarded to estimate the casual impact of aid on outcomes.

First, we exploit the variation in generosity in bursary awarded between institutions. Conditioning on parental income this compares students from a given parental income background but receiving different amounts of aid dependent upon which university they attend (see Figure 1). We allow for non-linearities in the the impact of amount awarded and parental income by including a squared term for each. To this basic specification we add a set of student characteristics, including entry qualification scores, and allow for differences in student outcomes across departments by including a set of indicators for each of the 22 subject areas. Effectively, we are comparing students with the same parental income, prior test scores and studying the same subject, but are attending different universities due to idiosyncratic preferences. However, one should be concerned that even after controlling for these

characteristics, student that attend high bursary institutions may attain better outcomes because these institutions are more 'productive'.

To account for this, the second source of variation we use is within university over time, through including university fixed effects. Since the enforced introduction of bursaries in 2006, there have been a considerable number of changes to bursary schemes within institutions (see Figure 2). We therefore exploit the variation in bursary awards within institution over time, effectively comparing two individuals of the same parental income background, but receiving different bursary awards due to their university entry year. Given the opaque nature of the student aid system for students applying to university it is unlikely that students delay or bring forward their enrolment at a specific institution in response to changes in bursary schemes.

The third source of variation is the most restrictive, exploiting the non-linear nature of the bursary schemes within an institution entry cohort, by including university-cohort fixed effects. All students entering a university in a given year are awarded financial aid based on the same set of rules relating to parental income. However due to the stepped nature of these schemes there are sharp discontinuities in the amount awarded for only small changes in parental income. For example, in Figure 2 we can see an individual with parental income of £15,000 in 2006 would have received a bursary of £3,000, but an individual with parental income of only £1 more would receive a bursary of £1,545. We only allow for the impact of parental income to change smoothly through the use of a quadratic term, and for the relationship between income and outcomes to be constant across all universities. The non-linearities in the means

tested bursaries at universities over time at different points of parental income provide us with variation to identify the impact of aid on student outcomes.[18]

Given the above discussion our preferred specification is the following:

$$y_{iuct} = \beta_1 A_{iuct} + \beta_2 A_{iuct}^2 + \beta_3 Inc_{iuct} + \beta_4 Inc_{iuct}^2 + \beta' X_{iuc} + \alpha_s + \mu_{uc} + \varepsilon_{iuct} \quad (1)$$

where *y* is the outcome of student *i* attending university *u*, who started in year of entry cohort *c* and in academic year *t*. This allows us to analyse the impact of aid on students outcomes in their first, second and third year of their degree. A is a continuous variable representing the amount of financial aid received by student *i* in thousands of pounds. Parental income *Inc* which the determinant of aid awarded is accounted for with a quadratic function. The detailed nature of the data also allow us to condition on a large vector of background characteristics of all undergraduates in the study (*X*), such as university entry grades, age, ethnicity and gender. Included with these we additionally control for the national student financial aid award (which is means tested but differs from bursaries since it is awarded at the national rather than institutional level, hence has no across university variation, and means tested gradually so does not feature multiple discontinuities).[19] As described, we account for average differences across subjects (α_s). Finally we include a set of university-year effects (μ_{uc}), which will provide us with the parameters of interest β_1, and β_2 which will provide the impact of an additional £1000 of financial aid on student outcome y at different levels of aid.[20]

[18] This is analogous to a multiple regression discontinuity design, but without estimating the impact at the cutoff points of the running variable (parental income) since we are not accounting for distance from each cut off. If we were to make a further assumption that the impact of a given amount of aid is constant over parental income (the slopes of the outcome being parallel either side of the cutoff), then the estimation would be equivalent.

[19] Excluding the national grant scheme in the set of student characteristics does not significantly alter any of the results.

[20] All standard errors presented are robust and clustered at the university level.

6. Empirical results

6.1 Main results

We being the analysis by building up the specification from a raw correlation to our preferred specification, which uses the variation in aid within university cohorts. Table 2 presents estimates of having an additional £1,000 of bursary awarded in the first year on the probability of eventually gaining a good degree, assuming a linear probability model. The outcome variable is defined as =1 if the student gains a first class honours degree or upper second and =0 if the student obtains a lower second, third class honours degree, or if they drop out of university before completion. This uses the sample of students that could have completed their degree (i.e excluding those students for whom we can only observe first or first and second years of study).

Column 1 contains the raw correlation: an additional £1,000 of aid is associated with a 4 percentage point increase in students' chances of graduating with a good degree, though the coefficient is not significant. There will be both positive and negative biases at play here. On the one hand, students from low income households are more likely to receive more financial aid, and are also less likely to achieve a good degree, generating a negative bias. On the other hand, students with high ability are more likely to perform well at university, and are also more likely to attend prestigious richer institutions, which can afford to give out bigger bursaries; these factors would generate positive biases.

In column 2 we address the first of these issues by controlling for up to a quadratic in parental income, and also allowing for the effect of bursaries to change non-linearly with the

amount awarded.[21] As expected, this raises the coefficient (since poorer students, who tend to have worse outcomes receive bigger bursaries). For ease of interpretation, beneath the estimated parameters for $\boldsymbol{\beta_1}$ and $\boldsymbol{\beta_2}$ (aid and aid squared) we present the marginal impact of £1000 of aid at the mean level of year 1 bursary aid (£862). Here the marginal impact of aid increases the likelihood of a student obtaining a good degree by 13.7 percentage points and is significant at 1%. Students with higher prior test scores are likely to achieve good outcomes regardless and to the extent that they also attend institutions which give out larger bursaries, not controlling for them would bias up the estimate. In column 3 we additionally control for student characteristics (test scores, age, gender, ethnicity) which reduces the marginal impact to 0.109.

In column 4 we account for any differences across universities by including university fixed effects. The impact at the mean holds stable. Column 5 adds year effects accounting for any general increase in the probability of achieving a good degree over time, which significantly reduces the impact of aid to 0.079. The final column presents our preferred specification which replaces the university and year effects with a set of indicators for each year university combination. This exploits the non-linear relationship between aid awarded and parental income. This shows that a £1,000 increase in bursary aid at the mean increases the probability of gaining a good degree by 6.9 percentage points. This coefficient is comparable to the work of Bettinger (2004), bearing in mind exchange rates and inflation, who finds that a $1,000 (£660 aprox) increase in Pell aid corresponds to a 4 percent reduction in the likelihood that students withdraw from college in first year.

What could be driving this increase in the chances of getting a good degree? We explore this in tables 3-4 by looking at the impact on completion of each academic year and annual

[21] Including university-cohort fixed effects before parental income reduces the positive bias, with the marginal impact of aid being 0.006, and remains insignificant.

course scores. All effects presented in these tables are the marginal impacts at the mean and are obtained from separate regressions. Table 3 first shows the impact of an additional £1,000 bursary award each year on degree completion in the current and subsequent years, in each case conditional on completion of the previous year. For example, in the first row and first column, we show the impact of aid in the first year on completing the first year. In the second column of the first row, we show the impact of £1,000 of aid received in year one on completing the second year, only amongst students who have completed the first year. Similarly, estimates for completing the 3rd year is conditional upon students completing the 2nd year and the final column shows the impact of £1,000 of aid received in year one on gaining a good degree, conditional on completing year the third year. In each case, the full set of controls and a quadratic in bursaries is used, and marginal effects at the mean are presented.

Bursary aid has a positive impact on completion - particularly completion of the concurrent year, with the effects fading out in subsequent years. Bursaries seem to be particularly effective in years one and two, where the effect sizes range between 7.4-8.2 percentage points per £1,000 of bursary. It is interesting that bursary receipt in year 1 has no impact on probability of completing year three, but does impact the chances of obtaining a good degree, conditional on completing 3rd year. This suggests that the impact of bursary aid, at least for year one on degree class, comes through improving course scores, rather than preventing drop out.

This is examined more fully in Table 4, in which we present the results for an additional £1,000 of bursary on mean standardised course scores each year. Again we see a largely positive impact of bursaries – with the impact of an additional £1,000 of bursaries in the first year generating a 0.11 standard deviation increase in course scores in that year. Again the effects again strongest in concurrent years and fading out over time. As hypothesised above, we do see a positive effect of bursary in year 1 on course scores in year 3.

In summary, our analysis shows a positive impact of bursary aid on degree performance, to the tune of 6.9 percentage points per £1,000. This positive impact appears to be driven by both an increased probability of completion (of as much as 8.2 percentage points) and improvements in test scores (of as much as 0.11 standard deviations). These impacts are sizeable. Around 62% of students in our sample currently obtain a good degree, whilst 86% complete their degrees.

6.2 Robustness Checks

We perform a series of robustness checks on our estimates to determine their stability. These are shown in Table 5. The first row presents the marginal effects of aid in the first year of study at the mean for our preferred specification and sample, with the outcome varying across the columns. The outcomes are complete the 1st year, standardised 1st year course scores, and obtain good degree in columns one, two and three respectively.

Our main specification only uses students who could have potentially completed their course. However, we have data on all students that are currently studying at these ten universities. Therefore the second panel shows estimates includes additional cohorts, including all current students (i.e. those for whom we can only observe to the end of first or second year), this increases the sample size by around 10,000. Reassuringly the estimates do not change significantly for completing the 1st year or 1st year test scores. We do not present estimates for Good Degree as they would be the same as the row above.

One of the arguments that we put forward is that comparisons can be made across universities, which we support by showing that there is common support in the entry test scores of students (See Figure 3). Three universities appear to be exceptions to this, university one has test scores mostly below that of the others, and universities nine and ten appear to only

enrol high ability students. Therefore in the third panel we re-estimate the results excluding these universities. Again this appears to have very little effect on the results.

Finally one may be concerned that the measure of prior ability that we condition on is also influenced by parental income. This would be a problem if students from low income backgrounds achieved lower test scores for a given ability compared to students from a high income background. This means when controlling for entry test scores we would effectively be comparing higher ability students from low income backgrounds to lower ability students from higher income backgrounds. To account for this potential issue we include an additional term where test scores are multiplied by log(1/(Income+1)). Once again this appears to have little impact on the estimate impact of financial aid on student outcomes.

6.3 Heterogeneity of aid impact

So far, we have shown that bursary aid improves students' degree performance by reducing dropout and improving test scores. In this section we explore what the optimal amount of bursary aid might be, and also whether certain students may benefit from bursaries more than others.

In Figure 4 we plot the impact of bursary aid on degree performance across a range of bursary amounts. This figure is a graphical representation of the results presented in column 6 of Table 2, for a range of bursary amounts. Increasing aid improves performance, although there are decreasing marginal returns. The impact of aid peaks at £2,254 – where aid above this point in fact proves to worsen student outcomes, although not significantly. Thus, in a world of no budget constraint, universities would spend £2,254 per student. This is an issue we will return to in Section 6.

Up to now, we have assumed that bursary aid has the same impact for all students. But of course it may be the case that some students benefit more from bursaries than others. To explore this we include additional terms allowing for the effect of aid to vary by parental

income. In Figure 5 we plot the marginal effects of bursary aid at different household income levels (deciles) from these estimates. Though our error bars are rather wide, meaning we cannot reject the hypothesis of equal effects across parental income, again the chart is indicative of diminishing returns; as parental income increases, so the impact of bursary aid is reduced.

Of course, it may also be the case that the optimal bursary amount differs according to the parental income of the student. We explore this possibility in Figure 6, which plots the predicted outcomes of students for different levels of bursary aid by three bands of household income (zero household income, household income of £25,000 per year – around the median in the UK, and parental income of £50,000 per year). Here we see that maximum returns to bursary aid are achieved at lower levels of aid for better off students than poorer students; the optimum bursary amount varies between around £1,000 (for the highest income students) and £2,000 (for the lowest income). This graph also illustrates that the expected outcome of students from high income backgrounds are significantly above those from low income backgrounds when no aid is present. Yet the lowest income group has the same expected outcome as the highest group when they are given £1,000 of financial aid per year.

Finally, we examine the effect of bursaries across student ability levels (as proxied by entry test scores). A common argument in the literature (Dynarksi, 2003; Guryan, 2004) is that providing aid to marginal students may be inefficient. For example, if it was found that aid had the most impact on low ability students completing the first year of university, and negligible impacts on high ability students, one could argue that aid is simply subsidising marginal students. This would be problematic if such students derive less benefit from their studies, for example by experiencing lower returns to their degrees (Tobias, 2000). Alternatively, if high ability students gained the most from bursaries, regardless of income, then bursaries would be relieving the liquidity constraints of high ability students, allowing them to gain more from university. This would be an argument in favour of merit based financial aid. Through

interacting the prior test scores with aid awarded, Figure 7 presents the marginal impact of aid over different entry test scores. Despite the wide confidence intervals, this is indicative evidence that bursary aid has a constant impact across all ability levels and implies that a means tested aid program is efficient.

6.4 Designing an optimal bursary scheme

As described above, the impact of student bursary aid varies according to parental income and the amount of aid given. In addition the amount of aid that is to be distributed is also subject to a minimum budget constraint; in the initial legislation universities had to spend at least 10% of tuition fee income. Since universities have different student profiles in terms of parental income and different budget constraints in terms of total students, each university will an individual optimal policy which we can now calculate.

In order to achieve this we must assume an objective function for universities. For simplicity we assume that universities want to maximize the sum of student outcomes, weighting each individual equally. Specifically universities want to maximize the following

$$Total\ Outcomes = \sum_{i=1}^{10} X_i * y_i$$

where y_i is the mean outcome of students from parental decile income group *i*, and X_i is the number of students enrolled from income group I. We use estimates from our preferred specification and additionally account for the interactions of aid and parental income. Universities will maximize by allocating different amounts of aid to students from different income groups, given the number of students in each income group. The mean outcome of a group (y_i) can be represented by the following equation:

$$y_i = \beta_1 Aid_i + \beta_2 Aid_i^2 + \beta_3 Inc_i + \beta_4 (Aid_i * Inc_i) + \beta_5 (Aid_i^2 * Inc_i) + \beta_6 Inc_i^2 + \beta_7 (Aid_i * Inc_i^2) + \beta_8 (Aid_i^2 * Inc_i^2)$$

Universities also face a budget constraint such that the total income received in fees that is to be spent on aid (in £000's) has to be greater than or equal to the amount spent on financial aid summed over all parental income groups. As 97% of courses charged the maximum tuition fees of £3,000 to students regardless of income, and a minimum of 10% of tuition fee income needs to be spent on financial aid we define a universities budget constraint as the following:

$$\sum_{i=1}^{10} X_i * 0.3 \geq \sum_{i=1}^{10} X_i * Aid_i$$

Therefore universities' therefore maximize student outcomes y_i with respect to Aid_i for each income group given the income profile of the students (Inc_i, X_i) and effects β_1 through β_8, given this constraint.

$$\frac{dy_i}{dAid_i} = \left(\beta_1 + 2\beta_2 Aid_i + \beta_4 Inc_i + 2\beta_5 (Aid_i * Inc_i) + \beta_7 (Inc_i^2) + 2\beta_2 (Aid_i * Inc_i^2)\right)$$

Taking first order conditions for each income decile and setting the total marginal impact of aid for group one to be equal to the total marginal impact of aid in the next income group, given the number of students in each group. [22] This will generate nine equations, plus one for the budget constraint, which means we can solve for the 10 aid amounts.

Figure 8 illustrates, showing the distribution of income and the resulting optimal bursary aid policies of two example universities from our sample. As the figure illustrates, University A is a relatively poor university, with high proportions of students from low income backgrounds, and few from high income backgrounds. Meanwhile, University B is a relatively rich

[22] The first order conditions are not all set to zero as the budget constraint is likely to bind before each group reaches its maximum.

university. For both types of university, the resultant optimal aid policies indicate that aid should be smoothly decreasing as parental income rises. For University B, the relatively richer university, the poorest students should receive more aid per head than at University A. This is because University B has more high income students who gain less from aid and also has fewer poorer students who gain more. Note the amount awarded to the highest income groups at the poor university is in fact higher than the 8th decile, this is because there are very few students at this income group that would receive the higher amount.

In Figure 9 we apply this optimisation to nine universities in our sample. In this Figure we show i) minimum optimal aid – this is the amount of aid each university should award students in each income decile, given the budget constraint, and ii) actual aid – the amount of aid each university actually awarded students in each income decile. As is apparent, every university in our sample awarded a greater amount of aid than the minimum required. This could be, for example, for reputational purposes. Given this, we also illustrate iii) optimal aid – where we set the budget constraint to be the actual total amount of aid spent by each university.

Figure 9 reveals the extent to which bursary spending is misallocated across income groups for each university. For example, university 4 chooses to award relatively equal amounts of aid to the students from the first 7 deciles of income. However, the optimal strategy would be to award poorer students the more aid, and decrease the amount of aid to those with higher parental income. On the other hand, University 8 has a different award

structure – over compensating higher income students and under-compensating lower income students according to what is optimal.[23]

6 Conclusion

Financial barriers to higher education have the potential to exacerbate existing earning inequalities. Our findings suggest that higher levels of bursary aid improve student performance. Students who have been awarded a bursary increase their likelihood of gaining a good degree by 6.9 percentage points for each additional £1,000 awarded. The effect is driven by both improvements in test scores and completion of the concurrent year. Our results are robust to different specifications and samples.

The institutional set up we study means that we can also examine heterogeneity in our effects. We find that the impact of bursaries is constant across ability levels, but decreases with parental income. Since low income students are less likely to have access to parental financial support, and are less likely to be able to obtain credit, this suggests that some of the positive impacts may be generated through relieving liquidity constraints.

[23] The optimal aid packages indicate that the amount of aid for the richest students (income deciles 9 and 10) is slightly higher than that for decile 8. This is an important caveat - because our data only contain parental income information on bursary holders, there are few students in these income groups, hence universities could afford to give such students higher amounts of aid.

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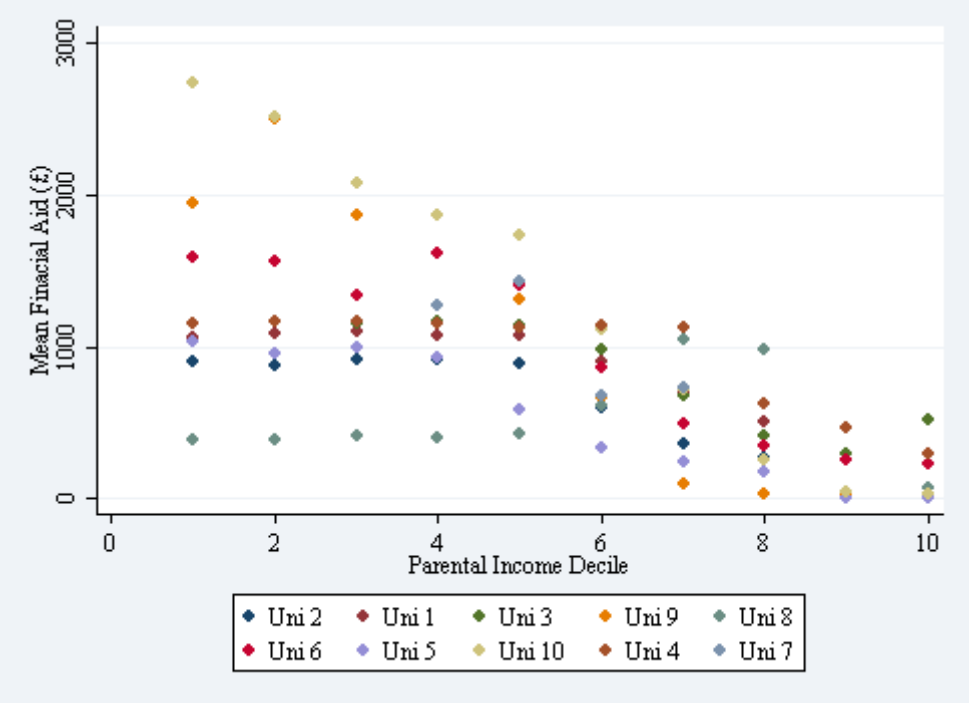
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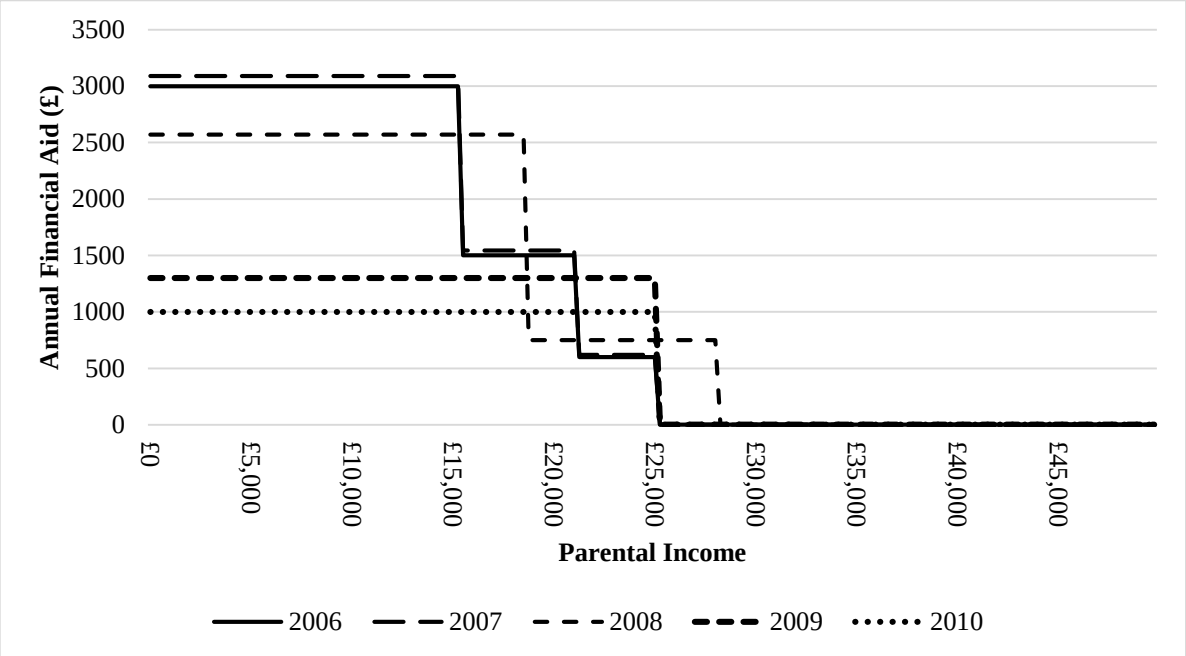
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Figure 1: Average bursary by parental income and university



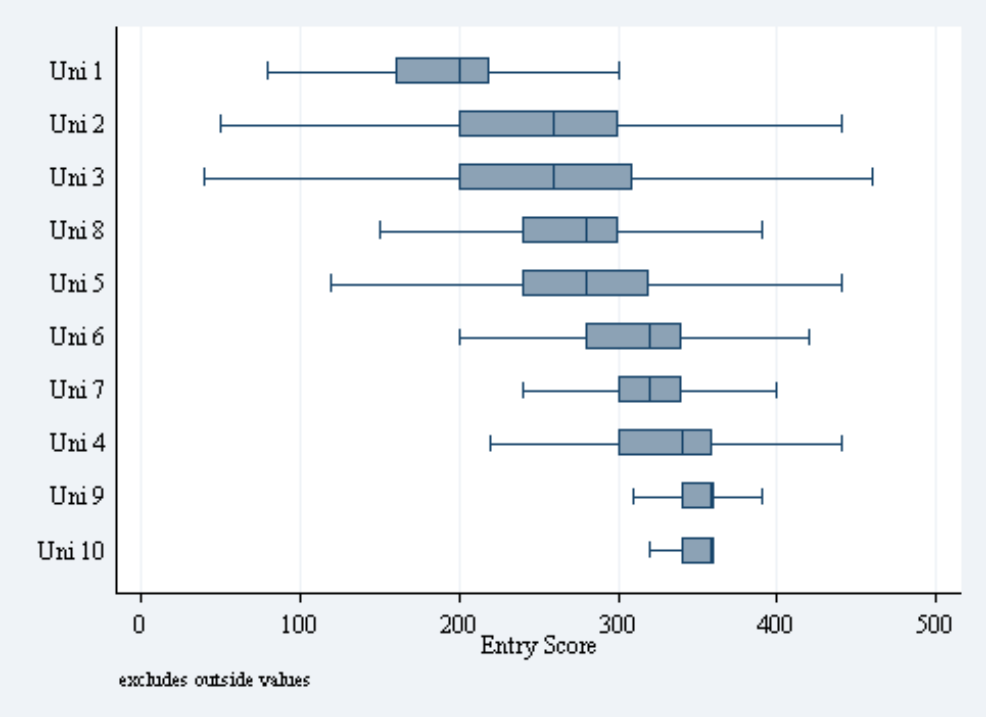
Notes: Each point represents the mean financial aid received at each university by parental income deciles of the estimation sample. Financial aid averaged over all academic years and cohorts. Source administrative data from the 10 universities.

Figure 2: Financial Aid Schedules at University X over time



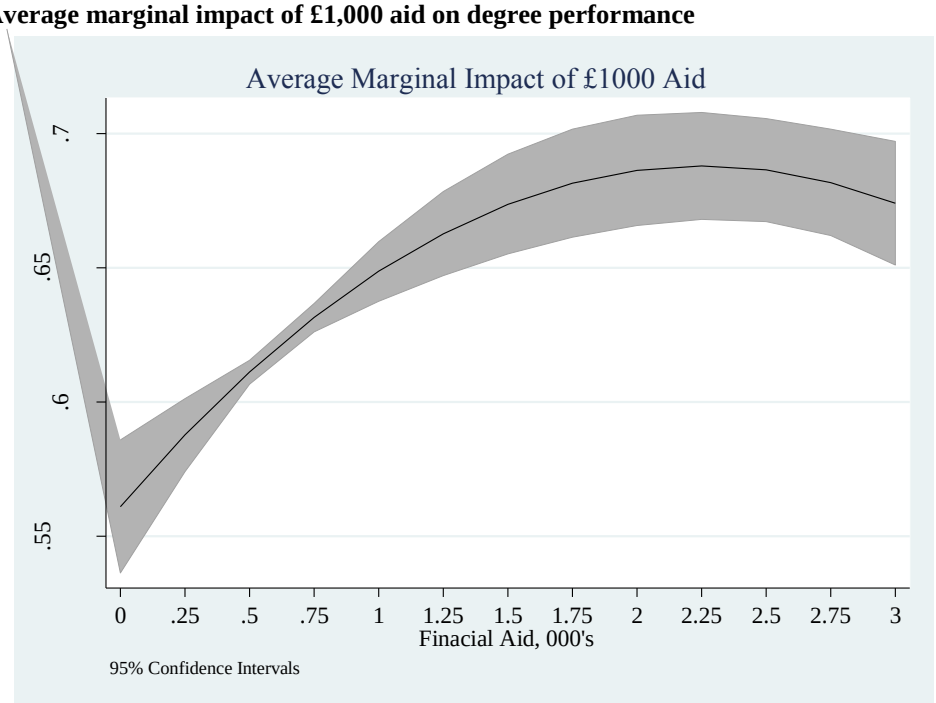
Notes: Figure 2 represents the financial aid schedules for first year students for an anonymous English university for students entering in the years 2006 through to 2010.

Figure 3: Entry scores by university



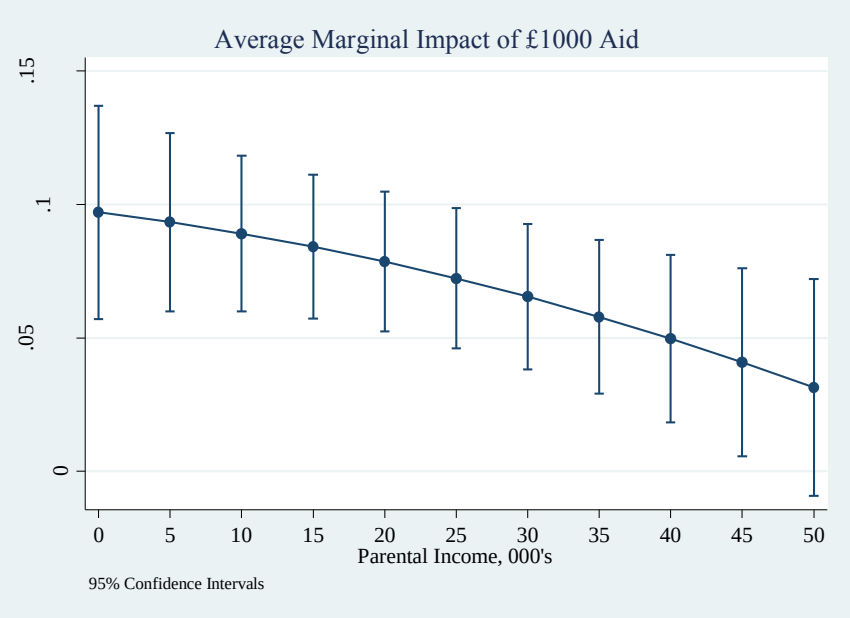
Notes: Figure 3 shows box plots of the entry qualification scores of students attending each university in the estimation sample. The ends of each box represent the 25th and 75th percentiles in entry qualification scores. Source administrative data from the 10 universities.

Figure 4: Average marginal impact of £1,000 aid on degree performance



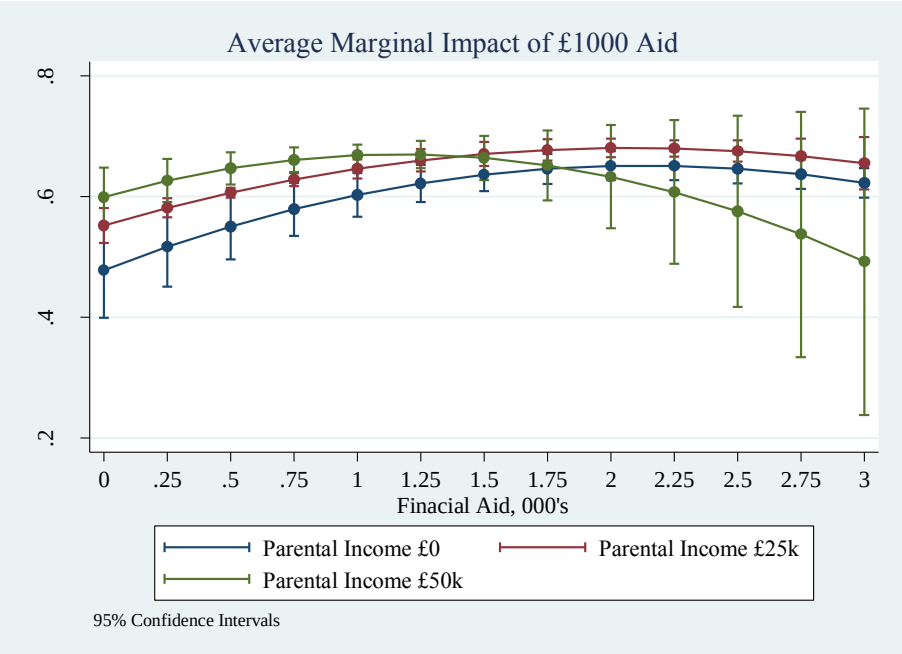
Notes: Figure 4 shows the predicted outcome of good degree for the mean student by amount of finical aid awarded. Estimates come from estimating specification 1, which can be found in Column 6 of Table 2. Standard errors clustered at the university level. Source administrative data from the 10 universities.

Figure 5: Average marginal impact of £1,000 aid on degree performance, across parental income



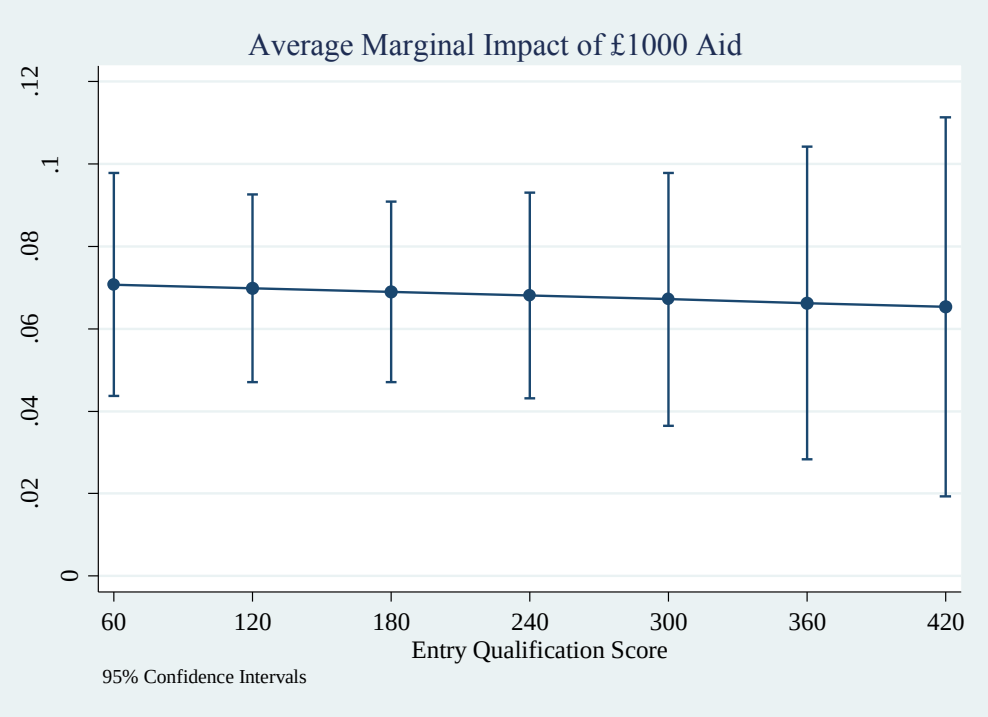
Notes: Figure 5 shows the marginal impact of an additional £1,000 of aid at different levels of parental income. Estimates obtained from specification 1 additionally with the parental income and finical aid terms interacted. Calculated using the margins command. Standard errors clustered at the university level. Source administrative data from the 10 universities.

Figure 6: Average marginal impact of £1,000 aid on degree performance, parental income groupings



Notes: Figure 6 shows the predicted outcome of good degree for students from three parental income groups (£0, £25k, £50k) amount of finical aid awarded. Estimates obtained from specification 1 additionally with the parental income and finical aid terms interacted. Calculated using the margins command. Standard errors clustered at the university level. Source administrative data from the 10 universities.

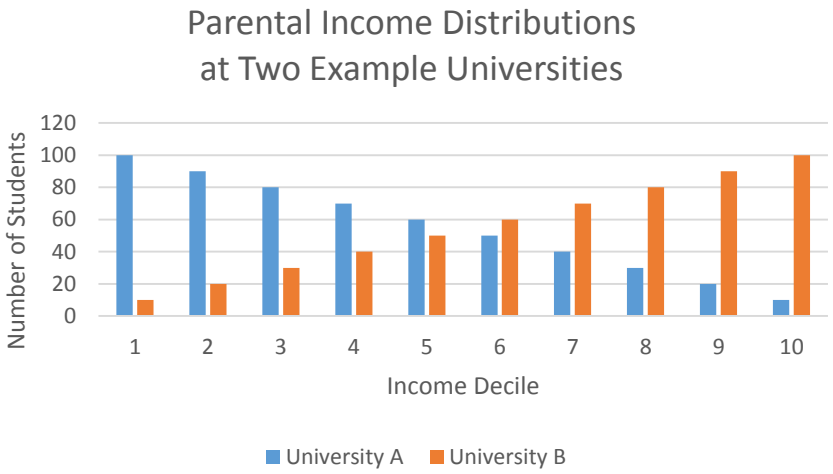
Figure 7: Average marginal impact of £1,000 aid on degree performance, across ability of student



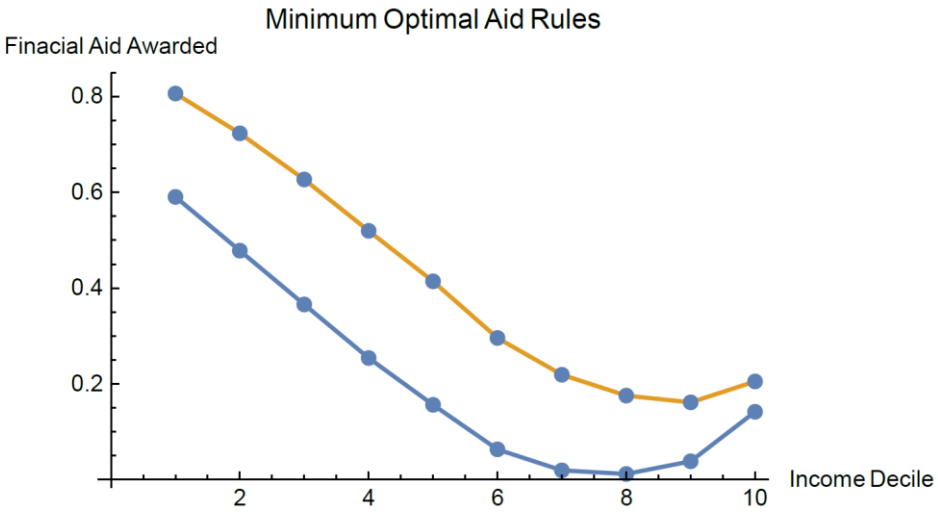
Notes: Figure 7 shows the marginal impact of an additional £1,000 of for the mean student at different levels of entry qualification. Estimates obtained from specification 1 additionally with the entry test scores and finical aid terms interacted. Calculated using the margins command. Standard errors clustered at the university level. Source administrative data from the 10 universities.

Figure 8

Panel A

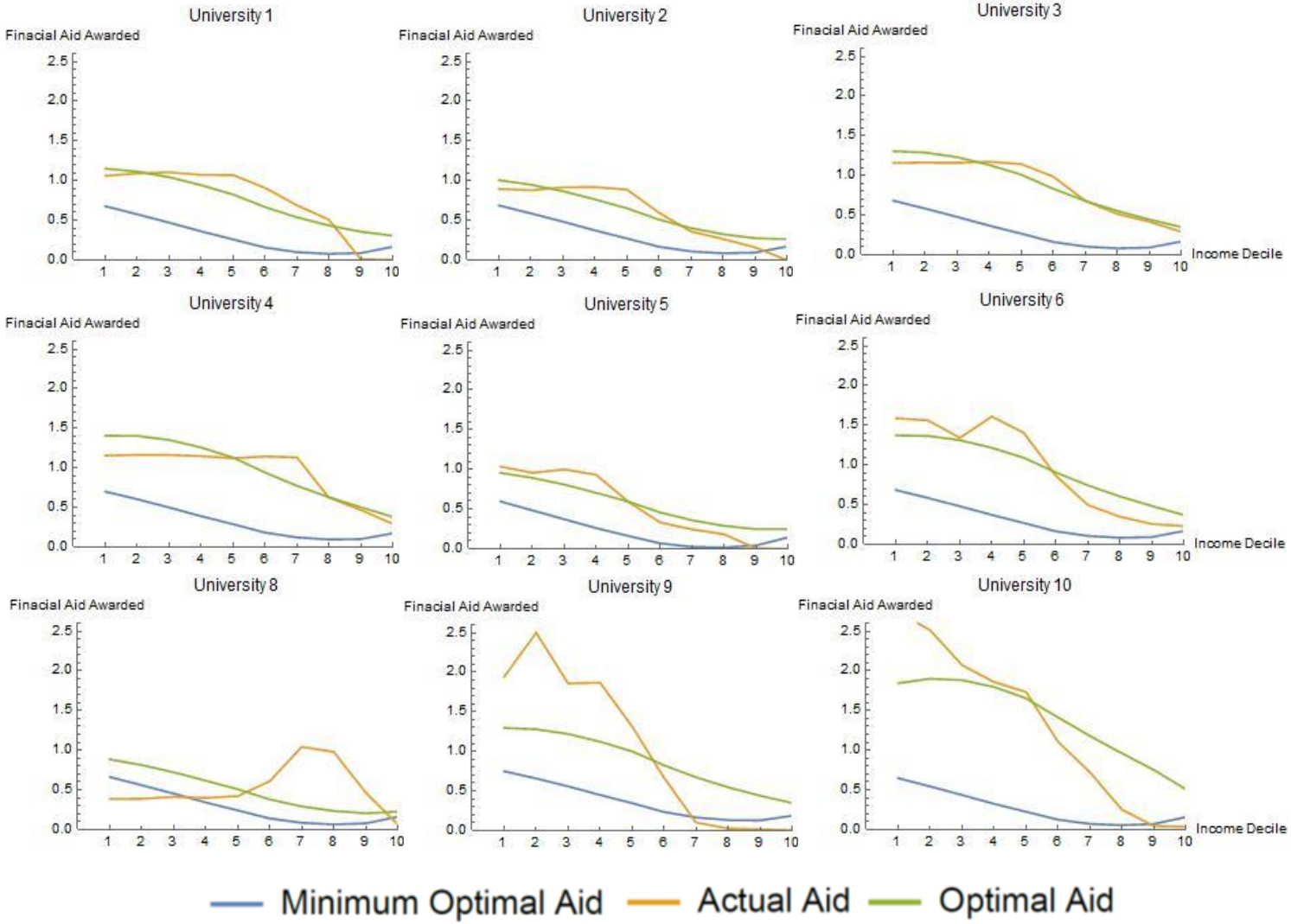


Panel B



Notes: Panel A of Figure 8 is a histogram of parental income deciles at two hypothetical universities. Panel B of Figure 8 shows the optimal amount of aid to be awarded to each income group at the two universities, given their student populations.

Figure 9



Notes: Figure 9 plots i) the optimal aid schedule for each university given their student populations at the minimum requirements, ii) their actual amount awarded and iii) given the amount the universities award each year, the optimal schedule.

Table 1: Characteristics and student outcomes

	Mean	Std dev.
Average bursary (£)	712.808	(611.137)
Bursary aid in year 1 (£)	862.269	(748.792)
Bursary aid in year 2 (£)	788.614	(749.033)
Bursary aid in year 3 (£)	780.989	(757.647)
Male (%)	0.427	(0.495)
Age on entry	18.626	(0.837)
White (%)	0.797	(0.402)
Household income (£)	28,000	(21000)
Entry test scores	283.637	(79.257)
Government aid (£)	1814.65	(1188.752)
Dropped out year 1 (%)	0.072	(0.258)
Dropped out year 2 (%)	0.034	(0.182)
Dropped out year 3 (%)	0.018	(0.133)
Dropped out year 4 (%)	0.005	(0.072)
Dropped out year>4 (%)	0.002	(0.044)
Course scores year 1	0	(1)
Course scores year 2	0	(1)
Course scores year 3	0	(1)
Completed degree (%)	0.869	(0.338)
Obtained good degree (% of all students)	0.626	(0.484)
Obtained good degree (as % of those completing)	0.720	(0.449)
N	23,093	

Notes: sample consists of those who have had a bursary at some point during university. Also sample consists only of those students whose final outcome can be observed

Table 2: Impact of financial aid on probability of obtaining a good degree

P(Good Degree)	(1)	(2)	(3)	(4)	(5)	(6)
1st Year Financial Aid	0.040	0.165***	0.148***	0.168***	0.125***	0.112***
	(0.028)	(0.048)	(0.035)	(0.031)	(0.023)	(0.022)
1st Year Financial Aid Squared		-0.016	-0.023**	-0.036***	-0.026***	-0.025***
		(0.012)	(0.009)	(0.008)	(0.006)	(0.006)
Marginal Effect at Mean	0.040	0.137***	0.109***	0.105***	0.079***	0.069***
	(0.028)	(0.030)	(0.022)	(0.018)	(0.013)	(0.011)
Parental Income		✓	✓	✓	✓	✓
Student Characteristics			✓	✓	✓	✓
University Effects				✓	✓	
Year Effects					✓	
University*Year Effects						✓
Observations	23,093	23,093	23,093	23,093	23,093	23,093

Notes: Good degree defined as being equal to 1 for those students obtaining a first class or upper second class degree, and 0 for all other outcomes, including drop out. Sample consists only of those students whose final outcome can be observed. Standard errors are in parenthesis, and are clustered at institution level.* $p < 0.1$. ** $p < 0.05$. *** $p < 0.01$

Table 3: Impact of financial aid on completion

	Complete 1st Year	Complete 2nd Year	Complete 3rd Year	Good Degree
Specification (6)	(1)	(2)	(3)	(4)
1st Year Financial Aid	0.074***	0.018**	0.003	0.023***
	(0.020)	(0.006)	(0.003)	(0.005)
Obs	*23,093*	*21,431*	*20,643*	*20,227*
2nd Year Financial Aid		0.082**	0.022**	0.022**
		(0.027)	(0.008)	(0.010)
Obs		*21,073*	*20,285*	*19,931*
3rd Year Financial Aid			0.039**	0.005
			(0.015)	(0.013)
Obs			*19,363*	*19,028*
Parental Income	✓	✓	✓	✓
Student Characteristics	✓	✓	✓	✓
University*Year Effects	✓	✓	✓	✓

Notes: Sample sizes vary by year as students drop out. Sample consists only of those students whose final outcome can be observed. Coefficients presented are of marginal effects at mean bursary amount. Standard errors are in parenthesis, and are clustered at institution level. * p < 0.1. ** p < 0.05. *** p < 0.01

Table 4: Impact of financial aid on course scores

	Test Scores 1st Year	Test Scores 2nd Year	Test Scores 3rd Year	Good Degree
Specification (6)	(1)	(2)	(3)	(4)
1st Year Financial Aid	0.111**	0.076***	0.080***	0.023***
	(0.034)	(0.017)	(0.013)	(0.005)
Obs	*19,248*	*16,196*	*14,618*	*20,227*
2nd Year Financial Aid		0.119**	0.072***	0.022**
		(0.050)	(0.014)	(0.010)
Obs		*16,162*	*14,581*	*19,931*
3rd Year Financial Aid			0.082*	0.005
			(0.035)	(0.013)
Obs			*14,546*	*19,028*
Parental Income	✓	✓	✓	✓
Student Characteristics	✓	✓	✓	✓
University*Year Effects	✓	✓	✓	✓

Notes: Sample sizes vary by year as students drop out. Sample consists only of those students whose final outcome can be observed. Coefficients presented are of marginal effects at mean bursary amount. Standard errors are in parenthesis, and are clustered at institution level. * p < 0.1. ** p < 0.05. *** p < 0.01

Table 5: Robustness Checks

	Complete 1st Year	Course Scores 1st Year	Good Degree
Specification (6)	(1)	(2)	(3)
Main Specification	0.074***	0.111**	0.069***
	(0.020)	(0.034)	(0.011)
	23,093	19,248	23,093
Include Current Students	0.067***	0.128**	
	(0.017)	(0.055)	
	34,026	28,333	
Exclude Outlying Universities (1, 9, 10)	0.069***	0.131**	0.078***
	(0.016)	(0.042)	(0.011)
	21,820	11,042	21,820
Account for Differential Effect of Prior Test Scores by Income	0.074***	0.107**	0.070***
	(0.020)	(0.032)	(0.012)
	23,093	19,248	23,093
Parental Income	✓	✓	✓
Student Characteristics	✓	✓	✓
University*Year Effects	✓	✓	✓

Notes: Sample sizes vary by year as students drop out. Sample consists only of those students whose final outcome can be observed. Coefficients presented are of marginal effects at mean bursary amount. Outlying Universities based on the lack of overlap in prior test scores with other universities. Accounting for test scores reflecting different ability by test scores, additionally controls for test scores multiplied by log(1/(Income+1)). Standard errors are in parenthesis, and are clustered at institution level. * $p < 0.1$. ** $p < 0.05$. *** $p < 0.01$

Appendix 1

All universities want to maximise the sum of student outcomes through use of aid subject to a budget constraint.

$$Max: \ Total\ Outcomes = \sum_{i=1}^{10} X_i * y_i$$

$$st \sum_{i=1}^{10} X_i * 900 \geq \sum_{i=1}^{10} X_i * Aid_i$$

Where y_i is the mean outcome of students from parental income group i, and X_i is the number of students enrolled from income group i. The budget constraint represent that the university a required to spend 10% of their fee income on bursaries and average fees are £9,000 per year regardless of parental income, and that total spending on Aid cannot exceed this.

Having estimated the following function and have found that mean outcome of a group (y_i) can be represented by the following equation.

$$y_i = \beta_1 Aid_i + \beta_2 Aid_i^2 + \beta_3 Inc_i + \beta_4 (Aid_i * Inc_i) + \beta_5 (Aid_i^2 * Inc_i) + \beta_6 Inc_i^2 + \beta_7 (Aid_i * Inc_i^2) + \beta_2 (Aid_i^2 * Inc_i^2)$$

Therefore the above can be re-written as the following

$$Max: \ Total\ Outcomes$$

$$= \sum_{i=1}^{10} \{X_i * (\beta_1 Aid_i + \beta_2 Aid_i^2 + \beta_3 Inc_i + \beta_4 (Aid_i * Inc_i) + \beta_5 (Aid_i^2 * Inc_i) + \beta_6 Inc_i^2 + \beta_7 (Aid_i * Inc_i^2) + \beta_8 (Aid_i^2 * Inc_i^2))\}$$

$$st \sum_{i=1}^{10} X_i * 900 - \sum_{i=1}^{10} X_i * Aid_i \geq 0$$

Universities' therefore maximise in terms of Aid_i given Inc_i, X_i and β_1 through β_8

FOC for aid of group *i*

$$\frac{dy_i}{dAid_i} = (\beta_1 + 2\beta_2 Aid_i + \beta_4 Inc_i + 2\beta_5 (Aid_i * Inc_i) + \beta_7 (Inc_i^2) + 2\beta_2 (Aid_i * Inc_i^2))$$

The university weights this effect by how many people are in this group.

$$\frac{dOutome(y_i)}{dAid_i} = X_i * (\beta_1 + 2\beta_2 Aid_i + \beta_4 Inc_i + 2\beta_5 (Aid_i * Inc_i) + \beta_7 (Inc_i^2) + 2\beta_2 (Aid_i * Inc_i^2))$$

Therefore the final system of 10 equations we want to solve is

$$\frac{dOutcome(y_1)}{dAid_1} = \frac{dOutcome(y_2)}{dAid_2}$$

Similarly for the other income groups

$$\frac{dOuctome(y_i)}{dAid_i} = \frac{dOutcome(y_{i+1})}{dAid_{i+1}}$$

Until

$$\frac{dOutcome(y_9)}{dAid_9} = \frac{dOutcome(y_{10})}{dAid_{10}}$$

With the final equation of the system being.

$$\sum_{i=1}^{10} X_i * 900 - \sum_{i=1}^{10} X_i * Aid_i = 0$$

This system of equations will allow us to estimate the optimal aid scheme for any given university given values for Inc_i and X_i.