Testing Means-Tested Aid

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January 2017

Abstract: Inequalities do not end once students enter college. Yet, much research on the effectiveness of financial aid examines its impact purely on enrolment. In this paper, we provide evidence on the impact of non-merit aid on the outcomes of enrolled students. Using data collected from nine institutions, we exploit a unique non-salient aid program which varies across and within institutions, and for which eligibility is a highly non-linear function of parental income. We find that each £1,000 of aid increases the chances of gaining a *good degree* by 3.7 percentage points, driven by increases in completion rates and course scores.

JEL classification: I22, I23, I28

Keywords: higher education, financial aid, degree completion

Acknowledgements: We thank Damon Clark, Susan Dynarski, Caroline Hoxby, Sarah Turner and John Van Reenen for their comments and suggestions. We would also like to thank participants of the AEFP 2016, NBER Education 2015, CESifo 2015 and Royal Economic Society 2014 conferences, the Russell Sage Foundation and the CEP, LSE, University of Texas at Austin and UCL Education workshops. We also thank Steve Barnes, Charley Greenwood, Prasanthi Ramakrishnan and Claudia Hupkau for their excellent assistance in collecting and cleaning the data. Wyness acknowledges ESRC funding (ES/L000105/1). All errors are our own.

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1. Introduction

Higher education (HE) finance has been long used as a tool to improve participation among disadvantaged groups (Deming & Dynarski, 2009; Dynarski & Scott-Clayton, 2013). But inequality does not end once students enter university. Low income students are more likely to drop out of college or perform poorly in exams even conditional on prior attainment (Crawford et al, 2016). And whilst college participation has grown substantially among young people from the poorest backgrounds over the past 20 years, their completion rates have remained stubbornly low (Bailey and Dynarski, 2011). Given the substantial returns to undergraduate degrees and degree class (Card, 1999, Feng and Graetz, 2015; Walker and Zhu, 2011), improving the degree performance of disadvantaged students is a key challenge for education policymakers. This raises the question: can financial aid be used to help equalize the outcomes of students once they are enrolled in college?

Establishing that financial aid helps students to complete college, separate from any enrolment effects, has important consequences for how universities should allocate their resources. If only the extensive margin mattered, and aid did not help students to progress whilst in university, then it would be more efficient for universities to target resources on outreach (OFFA, 2013). Or resources could be redistributed even earlier in the education life-course to ensure young people are academically prepared for college. On the other hand, knowing that aid does help student attainment means that institutions could take on students who might appear marginal (e.g. through widening participation programs) and then use aid packages to assist them through college.

In this paper we estimate the impact of financial aid on this intensive margin, by examining a non-salient aid program in which students are automatically enrolled and eligibility is solely determined by parental income. We exploit non-linear changes in the amount of aid received for small changes in parental income levels, using financial aid schedules which vary across institutions and over time. We reach two main conclusions. First, that aid matters even once students have enrolled in college through both improving college persistence and student grades. Second, that aid is most effective for low income, high ability students.

To date, the majority of student aid research has examined its effects on the extensive margin, specifically focusing on enrolment decisions (Kane 1995, Dynarski, 2000; 2003, Seftor and Turner 2002, Nielsen et al., 2010, Dearden et al, 2014, Barr 2016). The consensus from these studies is that aid programmes increase enrolment to the tune of around 1-3 percentage points per $1,000. However, there is comparatively little research estimating the causal effect of aid on the intensive margin, aside from those studies which look at merit based incentives on the outcomes of enrolled students (Scott-Clayton, 2011; Garibaldi et al., 2012; Joensen, 2013), which typically find such incentives improve student outcomes.

A small number of studies have examined the impact of aid on enrolled students. However, these studies have significant limitations. Most importantly, they are not always able to disentangle effects on the extensive margin. In other words, the prospect of aid receipt at university may be correlated with the extensive margin in terms a students' likeliness to attend college in general. Bettinger (2004), for example, uses discontinuities in the Pell Grant formula arising from family size to identify the impacts of aid, finding evidence of a positive effect of aid on college persistence. Similarly, Castleman & Long (2013) study the Florida State Access Grant (FSAG) exploiting a single discontinuity, and uncovering positive estimates of the impact of aid on persistence and degree receipt, for students with parental incomes around $30,000 per year. In both these papers, the discontinuities studied are likely to also impact the decision to attend college. The prospect of aid may also be correlated with a students' likeliness to attend a *particular* college, making it difficult to separate the effects of aid receipt from college effects. For example, students might be attracted to Ivy League institutions because of their high aid packages, and these institutions are also likely to generate better student outcomes.

A second limitation in the literature is that the effects of aid are not generalizable, since they tend to relate to specific groups and single discontinuities. For example Denning (2016) investigates the impact of Pell aid on enrolled students, around a specific discontinuity. His study, which finds that additional financial aid accelerates graduation, relates only to older students, and to students with parental incomes around this specific discontinuity. Goldrick-Rab et al (2016), meanwhile, provide experimental evidence of the impact of aid, finding an improvement in persistence for students at schools with low rates of persistence. But again the aid package is only available to very poor students (parental incomes of less than $30,000 pa).

A third limitation among these studies is that they are based on Pell grant funding, or funding conditional on Pell. Since Pell has federal standards requiring the student to maintain a minimum GPA and credit ratio, with over 40 percent of first year community college students failing to meet them (Schudde & Scott-Clayton, 2014), this funding is effectively conditional on performance, meaning these studies are effectively merit based.[1] As such there is very little research on non-merit based aid, with the exception of Castleman & Long (2013).

[1] Pell Grants have ongoing requirements called "Satisfactory Academic Progress" standards. The federal government requires that students on federal aid maintain a certain GPA and credit ratio, as well as complete their program within a specified timeframe, in addition to reapplying for aid every year. Colleges have some flexibility in how they implement the policy, but most require a 2.0 cumulative GPA and that students complete 2/3 of their credits attempted at the end of year 1.

Finally, in all of the papers so far discussed, students are required to apply for the aid package in question, meaning that any estimates are likely to be based on the more motivated and informed students.

In this paper we study a particular form of student aid – the English higher education bursary scheme – which has unique features which help to fill these gaps in the literature, and establish the causal impact of financial aid on student performance at university in a uniquely generalizable way.

The English higher education bursary system has no merit conditions, and is available to students of all ages. Crucially, it is also unadvertised to students, is highly opaque, and does not require students to apply to receive it. This, in conjunction with the intricacies and timings of the English university application system, make it near impossible for students to know how much bursary aid they will receive in advance of attending university, making it irrelevant to their college-going decision (Corver 2010; Calendar and Wilkinson, 2013). This ensures that bursary aid does not impact both forms of extensive margin, neither the decision to apply to college at all, nor the decision to apply to a particular college. Importantly for our estimation strategy, it also means that students cannot "game" the amount they will receive by misreporting parental income.

To estimate the impact of aid, we exploit different and changing financial aid schedules across nine universities and three cohorts. Thus, the first contribution of our study is that we exploit the existence of multiple discontinuities in aid across a wide range of parental income groups (reaching as high as $70,000 per year). This means our results are more generalizable than studies which exploit single discontinuities, typically at very low income levels. It also means that we are able to look at heterogeneity in the effects of aid across income and ability – this is unusual given that the literature typically exploits a single discontinuity or treatment. The second contribution is that the institutional features rule out effects on the extensive margin, making our paper unique in the literature.

Using administrative data that we collected on student finances and attainment before and throughout college, we show that each £1,000 of financial aid that students are eligible for in the first year increases the chances of obtaining a good degree by 3.7 percentage points. This is driven by improvements in both degree completion and course scores. We find that at the mean each £1,000 of financial aid awarded in the first year increases completion by 1.5-1.9 percentage points, and increases test scores by 0.03 to 0.06 standard deviations, depending on the year of study. We also find heterogeneity in the impacts of aid, specifically that low income but high ability students benefit the most, implying that an efficient aid package should be assessed on both merit and income background.

There are a number of channels through which an unconditional cash transfer might have an impact on student outcomes. Traditionally, student aid is thought of as a means to reduce liquidity constraints which may limit students' ability to learn. Hence a cash transfer might affect outcomes

through: a) enabling students to afford additional learning materials b) enabling them to fund a better living environment, or c) reducing the need to work during college, meaning they can concentrate on their studies (Bettinger et al, 2016). In addition to these financial benefits, there may also be psychological benefits to the receipt of aid. Students receiving funds may treat the interaction as a gift exchange, thus increasing academic effort, or alternatively could gain a confidence boost through the perception that aid has been awarded based on ability (Goldrick-Rab et al, 2016, DesJardins et al, 2010). Whilst our study cannot isolate the particular mechanism through which our cash transfer works, we find evidence of the existence of credit constraints among high ability students which this transfer is helping to alleviate.[2]

The remainder of this paper proceeds as follows. Section 2 outlines the UK student aid system, and the unique features of the higher education bursary scheme. Section 3 describes our dataset. Section 4 outlines our empirical strategy, whilst results, robustness checks and heterogeneity can be found in Section 5. Section 6 concludes.

2. Institutional setup

The UK higher education system is characterised by high tuition fees (set at £3,000 per year during the time period we study) and high financial support. These fees are typically not paid upfront, rather the government provides an interest free loan[3] that covers the entirety of the fees, which graduates pay off once they earn wages over a certain threshold. During our study-period the government also provided a non-repayable means-tested maintenance grant of up to £2,700 per year for students with parental incomes less than £17,500 (2006/7).[4] This amounted to a large level of state support; students starting in 2006/7 with zero reported parental income would receive £6,255 in maintenance loans and grants per year in addition to the loan covering their entire tuition fee liability.

The financial aid program that is the focus of this paper is the English higher education bursary scheme. This was introduced by the UK government in 2006, alongside the raising of maximum tuition fees from £1,200 to £3,000 per year, as a way to placate opponents of the fee increase

[2] Whilst our dataset does not provide information on how students use their bursary aid, an alternative dataset, the Student Income Expenditure Study, does contain this information. We explored this dataset and found suggestive evidence that, conditional on parental income, those with higher bursaries were no more likely to be in term-time employment, but did spend more on accommodation. However the data in question has small sample sizes and banded parental income information, thus limiting our confidence in these findings.

[3] The take-up rate of the tuition loans is 87% (SLC 2013). Loans were subject to RPI inflation. After the period of our analysis real interest rates were introduced in 2012.

[4]Maintenance grants were abolished in September 2016,and replaced with additional maintenance loans. This means higher education bursaries are now the sole non-repayable form of student financial aid. Bursaries also represent the sole form of aid which is governed at an institutional rather than a national level.

(Callendar & Wilkinson, 2013). As part of these tuition fee reforms English institutions were required to offer financial aid in the form of a bursary to all low parental income students, defined as those in receipt of a full maintenance grant. The minimum bursary for these students was set to be the difference between the full fee charged and the maintenance grant received, which was a sole function of parental income. Thus, the minimum bursary for the most deprived students 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 the tuition fee limit.[5]

Other than the regulations regarding minimum coverage described above, universities were provided with no guidance or research on how to allocate these funds. Rather, they were given complete independence in how much to give out and to whom. There is little published by institutions that explains how bursary amounts are determined within university. Cover (2009) states that "Institutions determine their bursary schemes to meet their own objectives, leading to a range of bursary levels and eligibility criteria across institutions." Indeed, in our sample there is substantial variation in bursary generosity across institutions, and amounts per holder ranging from as little as £50 to as much as £3,200 per year.

In practice, universities typically offered more than the minimum required on these forms of aid, and extended it to more students than they needed to. Thus, the bursary system became a substantial portion of aid, consisting of £300m in annual expenditure. Around 44% of students receive a bursary, with the average the amount received around £750 per bursary holder per year.

A. Variation of interest

The decentralised nature of this financial aid programme effectively solves first of the identification issues; that aid recipients are more likely to be from poor backgrounds. With the English bursary scheme, the definition of a poor student, and how much they receive in bursary, varies across institutions and within institutions over time. Therefore, while 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 illustrated by Figure 1, which shows the variation in bursary awarding rules by parental income. We see that for students of similar income backgrounds, there is a substantial range of bursaries on offer. For example, students with

[5] 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.

zero parental income could receive as little as £350 and as much as £3,200 per year, with variation arising from the university attended and year of entry.

In addition to the cross university variation, there is a large degree of cross-cohort variation within institution as universities experimented with their schemes. Figure 2 shows how the bursary schemes of our 9 universities changed across cohorts[6], with each panel representing a different university. Looking at University 1 in Figure 2, for example, the maximum bursary that could be received was set to £3,000 in 2006 and then subsequently decreased to £1,000 in 2010, while the maximum parental income of eligible students increased from £15,000 to £25,000 over the same period. Moreover the number of different levels of bursaries awarded at this university decreased from three to two.[7] Specifications with university and cohort fixed effects will be using this variation to estimate the impact of aid.

Our preferred method of estimating the impact of bursaries is to 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. Thus, we identify the impact of aid through imposing a smooth relationship of outcomes with parental income across universities and cohorts coinciding with sharp changes in aid eligibility. The range of cut-offs means that we're estimating the impact at range of parental income levels and amounts of aid.

B. Extensive Margin

We claim that we are identifying the impact on the intensive margin, because the bursary aid a student is eligible for at university cannot impact on their choice. This because of three institutional factors that make the bursary aid scheme non-salient.

First, each university has its own unique bursary scheme in place which typically changes on a yearly basis[8]. These schemes are rarely advertised in prospectuses or university guides and there is

[6] Note, whilst our period covers university entry between 2006-2011, some of our universities are left or right truncated

[7] In practise, for around half of institutions in our sample, 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 the remainder policy rule changes affect all students regardless of entry year.

[8] Universities must report their bursary offer to the Office for Fair Access (OFFA), the English fair access watchdog, in order to satisfy requirements that they are making efforts to widen participation. Universities that do not satisfy OFFA that they are taking steps to attract poor students may not charge fees above £6,000 per year. In practice, no university has ever been refused the right to charge higher fees.

no centralized comparison tool to help students understand what is on offer.[9] [10] Thus, in order to know what they are entitled to, students would have to actively search through the finance pages of each institution of interest, or be aware of the OFFA website (in which universities upload forms – often as long as 30 pages – describing their widening participation programmes, which include information on their bursary aid schedules).

Second, students face a large uncertainty at the time of application about which bursary scheme would be applicable to them. This is the result of the unusual setup of the English university application system. In brief, students apply for courses based on their predicted exam grades, receive conditional offers, and commit to a favourite and second choice institution– all before taking the tests which will eventually determine their entry (Corver, 2010). It is only once students have sat their exams and received their actual grades, a month before university starts, that they will know which university they will attend and hence which bursary scheme would be applicable. Crucially for our setup, this occurs at least seven months after they submitted their financial aid applications for government loans, the information from which is used to calculate bursary aid[11], making it impossible for them to "game" bursary receipt. Moreover, the reported parental income is validated by a government department against tax records, which again reduces the likelihood of gaming by students.

This highlights the third factor contributing to the non-salience of the bursary scheme; participation in the scheme is passive, that is, students do not have to apply for a bursary in order to receive one. This means it is possible for students to be in receipt of the aid and not know, because it will be paid into their bank accounts in the same instalment as their maintenance grant.

In addition to these institutional features, two recent papers provide empirical support that bursaries do not impact the enrolment choices of students in England. Calendar and Wilkinson (2013) survey students who enter English universities in 2008, coinciding with the mid-point year of our sample period. In accordance with the above, they point out that *"[students] are notified [about*

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[9] 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

[10] The lack of advertising may be unsurprising. Whilst universities may wish to demonstrate to OFFA, the regulator, that they have offered a generous bursary, they have an implicit disincentive to attract poor students since they require more financial aid and increase the potential for negative peer effects.

[11] The Student Loans Company (SLC), responsible for administering fee and maintenance loans, also administer the bursary program; each university supplies SLC with their bursary schedule, and in combination with the parental income information, SLC calculates how much each student will receive, making the bursary payment directly into the students bank account along with any maintenance loan or grant that is due to them, at the start of the first term of university. This means that it is possible that students are not aware that they are in receipt of a bursary as any payment received would be a combination of maintenance grant, loan and bursary.

bursaries] only after they accept a place, when it is too late to inform their entry decision and HEI choice", and *"A third of students surveyed had not yet been told whether or not they would receive a bursary, despite the fact that they were surveyed in October 2008 and had started their HEI course, or were about to."*

More substantive evidence that English bursaries do not influence enrolment choices of students has been provided by Corver (2010) who looks at the impact of bursaries on application to university using detailed administrative data. Corver uses individual-level UCAS data on students' choice of university at the time period when students rank preferences of conditional offers. He finds no influence of bursary eligibility on student choice.

Given the empirical evidence and institutional details, we are confident that bursaries do not, and indeed cannot, impact on the extensive margin. But bursary aid may still influence the intensive margin, by impacting students' likeliness to complete each year of their degree, achieve higher university course scores and achieve a good quality degree. This is where we now turn our attention.

3. Data and institutional compliance

This paper makes use of a unique administrative dataset collected from nine UK universities. The data comprise the entire undergraduate population of UK and EU students for up to six cohorts of students beginning their studies between 2006 and 2011. In order to obtain this data we contacted all 159 higher education institutions in the UK, asking them for individual level student data on attainment, parental income and bursaries awarded. Of these 50 agreed to share their data, and we finally received data from 25 England-based institutions, giving us a sample of 341,398 students. As our estimation strategy relies on using the variation in financial aid for a given level of parental income to estimate the effect of bursaries on student outcomes, we first discarded universities who did not provide parental income or those at universities that only provided banded parental income. This reduced our sample to nine universities. We then discarded those students undertaking vocational courses or those above or below degree level. This reduced our sample substantially, leaving us with 35,879 students.

To provide descriptive evidence on the representativeness of the universities in our final sample, we present Table 1, which shows mean university characteristics of those in the sample to all other higher educations in the UK, from the Higher Education Statistics Agency (HESA). Our sample is well matched to the sector as a whole, being close to the average in terms of gender, ethnicity and disability. Students in our sample are slightly younger, however; 42% are under 21, versus 37% of students in the sector as a whole, and are also more likely to get a first or an upper second class degree

than the UK average. These differences may stem from some of the institutions in our sample having fewer non-traditional, older students.

Our sample is truncated, meaning we observe students who started in the earlier cohorts all the way through their studies (3 years), whilst we can only observe the first or second year of students who started later, 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 22,770 students. In a robustness check, we estimate the impact on outcomes during the first two years of university for students who have enrolled in the applicable years, including continuing students i.e. the full sample of 35,879 students for completing the first year.

The dataset tracks students throughout the course of their degree. Therefore we have information on each student's final degree outcome, including whether they dropped out, their year of drop out, and their average annual course scores. Since these scores are not comparable across universities or individuals, we standardise test scores by university, subject and year.

In Table 2 we present some descriptive statistics on the individuals in our full and main samples (as opposed to the mean of university characteristics as in Table 1). The average bursary per student during the first year is £775. To compare this to the state aid programme that is intended to relieve liquidity constraints, in 2006/07 a student with zero reported parental income would receive a total of £6,255 comprising of maintenance loans (£3,555) and grants (£2,700). In our sample the average bursary aid this student would also receive is £1,138 (i.e. some 42% of grant aid).

Average parental income in our sample is £23,288 – though we only observe the parental income data of students who provide their data to the SLC (see Section 2, p10) for means-testing of student maintenance loans and grants. Since the upper limit for means-testing is £50,000 we generally observe the parental income of those at or below this limit. Students receive on average £2,035 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 38% on grant aid.

In our sample the university completion rate is 90% meaning that only 10% of students fail to complete university. This is compatible with the dropout rate from UK official statistics, of around 8% (HEFCE, 2013) bearing in mind our stricter (degree students) and poorer (income typically under £50,000) sample. Drop out is highest in first year, at 5%, and steadily declines.

Our main outcome measure is whether a student obtains a *good degree*. Unlike the US, students in England rarely drop out from college, however this means many students graduate with low marks. To differentiate students in the subsequent labour market much emphasis is placed on the final grade of the student's degree. The possible grades awarded are Fail, Third Class, Lower Second Class,

Upper Second Class and First Class degrees. We define students obtaining a good degree as those being awarded a First or Upper Second Class degree (or 2.1). We choose this particular outcome as it is widely accepted in the UK labour market that achievement at this level is a key differentiator for employers. Indeed, graduates with a first or 2.1 have been shown to earn around 8% more than those with lower class degrees (Feng & Graetz, 2015, Walker & Zhu, 2013). This is also often the minimum requirement for entry to graduate programmes. 63 percent of all first year enrolees in our sample obtain a good degree. As a point of comparison the six-year graduation rate for students who started in the fall of 2006 was 60.5 percent at public four-year colleges, and 62.5 percent at private non-profit colleges (Shapiro et al, 2014).

Despite the strict institutional setup described in Section 2, we observe a degree of non-compliance in our data. This is illustrated in Figure 3, which plots household income and bursary eligibility versus receipt for our nine universities in one particular year (2008). As can be seen in this figure, the vast majority of students receive the bursary amount that corresponds with their observed household income. However in a small but significant number of cases, students receive more or less than they are entitled to. Across all our universities, we observe varying rates of non-compliance, with the average of around 5% of students receiving a bursary that is "too high" and around 7% receiving a bursary that is "too low".

A concern is that these issues are not simply random measurement error, but are arising from systematic issues that could generate biases. Administrators at these universities stated three situations where the amount of bursary received does not equal that which should be received for that level of parental income. First, a reassessment of parental income indicated that the student would be eligible for a different student aid amount (either due to student error, or a sudden change in circumstances), this would downward bias the estimates. The second type of non-compliance concerns student pre-dropout. If students register for a course, but then withdraw from the course before arrival, they will not receive a bursary but may still be recorded in the administrative records. Typically, such students would have been removed from the data, but it is possible that they could still appear as receiving zero bursary and dropping out in year one, which would bias our estimates upward. The third example of non-compliance concerns the university using its discretion to award additional funds to some students. If it is the case that institutions are systematically awarding high ability students more than they are entitled to, this will again bias our estimates upwards.[12] In order to eliminate the biases caused by this non-compliance, we instrument the amount of aid received with

[12] Despite students' prior test scores being uncorrelated with indicators of whether the students more or less than their designated amount, one my still be concerned that those receiving more may have other unobservable positive abilities.

using the amount of aid that the student is eligible for. This is described in more detail in Section 4 below.

4. Estimation strategy

Our empirical strategy exploits two sources of variation in financial aid awarded. First, we exploit variation in bursary aid for a given parental income within university over time, which arises due to the changes to bursary schemes within institutions, conditional on a set of student characteristics.

A second source of variation is more restrictive. We purely exploit the non-linear nature of the bursary schemes within an institution entry cohort. For example, in University 1, 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. Identification comes from exploiting this highly non-linear relationship between aid received and parental income.

In this specification we additionally include university-cohort fixed effects, again accounting for up to a third order polynomial in parental income, and nonlinear controls for entry test scores, student characteristics and subject area studied. This method ensures that student outcomes should vary smoothly with parental income and so we attribute any remaining non-linearities to the impact of bursaries.

Our empirical strategy is somewhat similar to the "heavily parameterized regression kink design" (Clark & Del Bono, 2016), which in turn is analogous to "regression kink design" (Card et al. 2012, Dong, 2010), but requires a stronger assumption, specifically that our third-order polynomial in income must capture the underlying outcome-parental income relationship across the full range of scores. Following Clark & Del Bono, we provide two validity tests of this assumption. First, we test if there is an "effect" of bursaries on pre-determined characteristics, in this case, university entry scores. This test is to ensure that there are no other sharp discontinuities that may be generating the effect (e.g. ability). Second, we check our estimates are robust to alternative polynomial specifications.

In addition to these assumptions, we need to satisfy those required for standard regression discontinuity designs; that students are similar each side of the cut-offs and students cannot dictate the treatment status by 'gaming' parental income (Lee & Lemieux, 2010). Given the institutional setting there are three strong reasons to believe that students are not sorting around these cut-offs. First, students don't know which university they will be attending until very late in the process. Two, students are not aware of the bursary rules due to the opaqueness of the schemes, and the fact that they need not even apply for bursary aid in order to receive it. And third, the parental income is validated by the government, therefore making it hard to cheat without consequence. Regardless, in

addition for checking for discontinuities in predetermined characteristics, we also check differential densities each side of the cut-offs using Cattaneo, Jansson, and Ma (2016) density tests.

Whilst our estimates, in line with standard regression discontinuity designs (Jacob and Zhu, 2012) will generate local estimates, i.e. the impact of aid for students close to the discontinuities, the presence of multiple discontinuities across much of the parental income range allows us to use all of the data to help identify the effects of interest, and results in a more generalizable effect than that generated by estimations around a single discontinuity.

We instrument the actual aid amount awarded with the amount of aid the student is eligible for, according to the university's own rules. In the first stage, the size of the aid coefficient therefore represents the average increase in aid for a unit increase in the aid they are eligible for. The second stage estimates the relationship between students' aid as predicted by the rules and the outcome of interest. Specifically we use the following equations:

$$y_{ijt} = \beta_1 \widehat{Aid_{ijt}} + f(Inc_{ijt}) + \beta X_{ijt} + \delta_{jt} + \varepsilon_{ijt} \quad (1)$$

$$Aid_{ijt} = \mu(Eligible) + f(Inc_{ijt}) + \beta X_{ijt} + \delta_{jt} + \varepsilon_{ijt} \quad (2)$$

where *y* is the outcome of student *i* attending university *j*, who started in year of entry cohort *t*. *Aid* is a continuous variable representing the amount of financial aid received by student *i* in thousands of pounds. Parental income *Inc* is accounted for with a third-order polynomial 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, gender and subject of study. In keeping with our estimation strategy, we control for these characteristics in the most flexible way possible, using dummies for each age, gender, ethnicity type, and for university entry grades (the latter variable spans from 0-300, therefore we have a series of 30 dummies for each 10 point range in entry grades). We additionally control for the national student financial aid award (maintenance grants), 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 only has two kinks.[13] Finally in our most demanding specification we include a set of university-year effects (δ_{jt}), which will provide us with the parameter of interest β_1 the impact of an additional £1,000 of financial aid on student outcome y, exploiting the nonlinear jumps in bursary awarded for a small change in income within

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

an institution year group. We also present estimates that use the within university variation over time, by including the institution and the year dummies separately.[14][15]

5. Empirical results

5.1 Main Results

At this point in a standard RD paper, one would traditionally plot the relationship between the outcome of interest and the running variable, on either side of the discontinuity. However, in our case, not only do we have multiple discontinuities, but in four of our nine universities, the aid schedules have slopes. Therefore in Figure 4, we plot the proportion obtaining a good degree against distance in parental income from the nearest cut-off for universities without slopes. We restrict the sample to students within £10k of their nearest cut-off and as in our main specification we have a flexible functional form for parental income (3rd order polynomial). Here we see that students below the cut-off have better outcomes than those just above the cut-off, providing suggestive evidence of a positive impact of bursaries. Note that this is with a much reduced sample size (n=9,093) because of our restriction to those universities with discontinuities in their schedules. There are also two reasons why there is a large spread of outcomes each side of the discontinuity. First because of the different rates of students obtaining good degrees across our universities and courses, and second because students are at different points in the parental income distribution (though they are above and below cut-offs). In response to this, we estimate the main specification (1) on good degree but omit the aid parameter and plot the residuals against distance from cut-off. This has the advantage of allowing us to focus on the variation of interest, and is shown in Figure 5. Again we see that students have better outcomes just below the cut-off than those just above it. Finally, in Figure 6 we plot the residuals as above, but against eligible aid. This semi-parametric means of displaying the main effects has the advantages of utilising the entire sample, as well as accounting for differences across universities. We see that over the first £500 of bursary aid, students perform better than those with zero aid. For bursaries between £500 and £1500, however, the effect of bursary aid levels off. For bursary levels above £1,500 the confidence intervals become extremely wide, since few individuals receive bursaries at such high levels. Given this observed relationship, we allow for decreasing marginal returns to aid in our specifications.

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[14] All standard errors presented are robust and clustered at the university-year level.

[15] We also estimate all of our models using log bursaries as the dependent variable (rather than bursaries and its square term in the model). We find these estimates to be qualitatively similar to those in our preferred specifications, but the quadratic is a better fit since it allows for more flexibility in the diminishing rates of return.

We use a manipulation test proposed by Cattaneo, Jansson, and Ma (2016) (CJM), building on the McCrary (2008) test, to test for students gaming the system. This would be seen by there being a higher concentration of students immediately below these discrete cut-offs. The CJM test is a data-driven approached based on a local polynomial density estimator, which does not require pre-binning of the data and automatically specifies bandwidths each side of the cut-off. For this sample of individuals, the CJM test proposes bandwidths of £1859 and £1850 to the left and right of the cut-off respectively. This leaves an effective sample of N-=424 and N+=400 for treatment and control groups respectively. The manipulation test value is T=0.827, with a p-value of 0.408, and therefore as expected due to the nature of the institutions, there is no statistical evidence of systematic manipulation of the running variable or sorting across universities.

We now use the empirical strategy described above to estimate the causal effects of means tested aid on enrolled students' outcomes such as obtaining a good degree, completing the three years of university and test scores in each year.

A. Obtaining a 'Good Degree'

Table 3 reports our estimates of the impact of bursary aid on the probability of obtaining a good degree. In Panel A, we assume constant returns to financial aid, whilst in Panel B we allow for decreasing marginal returns by adding a quadratic term in aid where we report the effects for aid and aid squared. For ease of interpretation, we also present the marginal impact of £1000 of aid at the mean level of year 1 bursary aid (£775). Here, the raw correlation between aid and outcome (in Column 1) implies each £1000 of aid at the mean results in a 0.5 percentage point reduction in students' chances of graduating with a good degree (column one, Panel B).

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 likely to perform well at university, and are also more likely to attend prestigious richer institutions, which can afford to give out bigger bursaries, generating a positive bias. To account for these, we sequentially account for parental income, student characteristics (age, gender, ethnicity) including entry test scores, university and year fixed effects. By column 5 we are using the variation in bursary aid schedules over time within universities, and the non-linear relationships between aid and parental income as all other characteristics have been dummied out. The results in column 5 which exploit the variation in aid within university across time imply that a £1,000 increase in bursary aid at the mean increases the probability of gaining a good degree by 7.9 percentage points. The final column (6) replaces the university and year effects with a set of indicators for each year university combination. This only exploits the non-linear relationship between aid awarded and parental income and is our

most restrictive specification. Here we find a £1,000 increase in bursary aid at the mean increases the probability of gaining a good degree by 7.1 percentage points.

To address for the potential of endogenous non-compliance we repeat the above estimations using the bursary aid eligibility, instead of aid received. These parallel set of results are presented in Panel C, where we find the marginal effect at the mean to have over halved in size, to 3.1 and 3.2 percentage points respectively for columns 5 and 6. In Panel D, we present our preferred estimates, which instrument the aid received with the amount eligible. As expected these 2SLS estimates are lower than the original estimates. As before there are decreasing returns to the amount of bursary aid, with the maximum impact that aid could have occurring at £1906 (Col 6 Panel D). Here, the marginal effect coefficient reveals an increase in the possibility of gaining a good degree by between 3.6 and 3.7 percentage points respectively, for a £1,000 increase in aid (significant at the 1% level).

As the endogenous variables are aid and its square, instead of showing the first stage estimates and the associated F-Statistics, we present the Shea's adjusted partial R-squared. In accordance with having similar reduced form results, the high values indicate that the aid rules are very good predictors of amount of aid received.

Note the results from our most demanding specification, exploiting only the non-linearities in aid within university cohorts are very similar to those in which we also exploit the variation arising from changes in bursary rules across cohorts within university. The latter is a more restrictive specification, but has the advantage of using more variation, and as the results indicate, may be sufficient. From this point onwards we only discuss results based on the specification using university-cohort fixed effects.

B. Degree Completion and Course Scores

What could be driving this increase in the chances of getting a good degree? We explore this question in Tables 4-5 by looking at the impact on completion of each academic year and annual course scores. All effects presented in these tables are the marginal impacts at the mean and are obtained from separate regressions. Table 4 first shows the impact of an additional £1,000 bursary award in first year on completion of the first, second and third years, along with good degree for comparison purposes. Note students must complete each year to obtain a good degree. In each case, the full set of controls and a quadratic in bursaries is used. For our preferred 2SLS estimator (Panel B), we find evidence that bursary aid has a positive impact on completion. We find a £1,000 increase in aid improves students' likeliness to complete the first year of the degree by 1.4 percentage points.

The impact of aid on completion increases with each year (1.6 2nd year, 1.9 3rd year). Intuitively it would be difficult for these effects to decrease, as if £1000 of aid increased the

probability of completing the first year by 1.4 percentage points, then it will have at least this impact on students ever completing the second year, unless second year aid has a negative impact. Therefore these increases in the coefficients represent the marginal impact of aid. Note this will be a combination of aid receipt in the first and second year, as these aid amounts are highly correlated. These effects are comparable to those found by Bettinger (2004), who finds that a $1,000 (£660 approx) increase in Pell aid corresponds to a 4 percentage point reduction in the likelihood that students withdraw from college in first year, given exchange rates and inflation.

Note that in all cases we use eligible aid according to parents' stated income prior to entering college. As previously described this is hard to game since students would be unaware of the bursary schedule of their chosen university prior to entry. Using eligible aid in subsequent years based on concurrent parental income runs the risk of students/parents potentially manipulating income (e.g. by declaring a marital separation) based on their knowledge of the bursary schedule. Effectively we use aid in first year as a proxy for aid in subsequent years.

The impact of aid on completion of final year is lower than the impact of aid on obtaining a good degree – suggesting there may be some additional impact of aid coming through course scores. This is examined in Table 5, in which we present the results for an additional £1,000 of bursary on mean standardised course scores each year. Here we see a largely positive impact of bursaries – with the IV estimator showing an additional £1,000 of bursaries in the first year generating a 0.064 standard deviation increase in course scores in that year, a 0.041 standard deviation in course scores in the second year, and an insignificant impact in the third year of 0.03. However these estimates will be biased by sample selection due to treatment; as established in Table 4, treatment status impacts completion of each year. Therefore in Panel C we present banded estimates, in which we replace missing values of course scores with the standardized minimum and maximum test scores within each university, course and year of entry group. For the first and second year of study we find that the lower bound estimates continue to be significant at the 10 percent level, at 0.043 and 0.036 respectively. By the third year, the underlying spread of scores is wider and we are replacing more students due to dropout, and as such the bounds are wider. The lower bound is insignificant but remains positive, at 0.018 while the upper bound is both positive and significant at 0.091.

In summary, our analysis shows a positive impact of bursary aid on obtaining a good degree, to the tune of 3.7 percentage points per £1,000, against a mean good degree rate of 62 percent. This positive impact appears to be driven by both an increased probability of completion (of as much as 1.9 percentage points) and improvements in test scores (of as much as 0.064 standard deviations). These impacts are comparable to those obtained by Bettinger (2009).

5.2 Robustness Checks

We perform a series of robustness checks on our IV estimates to determine their stability. These are shown in Table 6. The first row again presents the marginal effects of aid in the first year of study at the mean for our preferred IV models and outcome measures. The outcomes are complete the 1st year (Column 1), standardised 1st year course scores (Column 2), and obtain good degree (Column 3).

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 9 universities (i.e. those for whom we can only observe to the end of first or second year). Therefore the second panel shows estimates including the additional cohorts of all current students. This increases the sample size by around 13,000 to 35,879. Reassuringly the estimates are very similar when including these additional observations.

In general, all of the universities have a wide range of prior attainment test scores, i.e. there is common support in the entry test scores of students. Three universities appear to be exceptions to this; university one and eight appear to only enrol students with the highest of test scores, and university two appears to enrol students whose test scores are mostly below that of the others (see Appendix Figure A1). Therefore in the third row we re-estimate the results excluding these universities. Again this appears to have very little effect on the results.

Similar to a regression discontinuity paper, we want to establish that treated individuals are similar to the untreated. In the case of a heavily parameterised regression kink design, we want to show that bursary receipt is uncorrelated with any pre-determined characteristic. To do this we estimate the impact of bursary aid on the set of pre-defined student characteristics using our main specification, omitting all student characteristics apart from parental income. These results are shown in Table 7, and we find that there is no significant relationship with any of the pre-determined variables using any of the sub-samples.

The other critical assumption needed for this estimation strategy is that the functional form of the running variable is sufficiently flexible, that is, with the highly parameterised specification the relationship between parental income and the outcome is smooth. To test this we present estimates with alternative polynomial specifications of parental income, from linear up to quintic, on first year test scores, completion and obtaining a good degree. These can be seen in Table 8, and show that our results are robust to the order of polynomial, and the cubic relationship we use throughout is sufficient.

5.3 Heterogeneity

We now consider whether the relationship between bursary aid and outcomes varies according to student characteristics by re-running our main specification for different groups according to gender, ethnicity, parental income and prior test scores. These results are presented in Table 9.

As can be seen, we see little difference in the impact of bursary aid by gender. The marginal effects are similar for completing the first year, course scores, and obtaining a good degree – although, for the first of these the estimates are only significant for males. For age we see there are distinct and significant differences in the impact of bursaries according to the age of the student. The positive impact of bursaries appears to be driven solely by traditional age students (those who enter university at a young age, less than 20 years old), rather than more mature students.

A common concern among higher education policymakers is that that need based aid may simply subsidize college for infra-marginal students – those who may not benefit from college but are induced into it due to the low costs (Dynarski, 2003). Unlike papers which focus only on the extensive margin, we can directly test which types of students go on to benefit from aid after enrolment, in terms of both disadvantage, and ability. Thus, we are able to estimate the impacts along two dimensions that a student may be marginal, ability and liquidity. In each case, we run regressions split at median of that characteristic for all students in the sample. For ability we also create categories for "relatively high ability" and "relatively low ability" students, here defined as above/below the median of all students within the student's university of attendance.[16] We believe these findings will be more informative for forming individual university aid policies based on merit.

First, in terms of parental income, we find that the poorer students in the sample gain considerably more than richer students. The estimated impacts for students in the lower half of the distribution are around four times higher than estimates on the whole sample for all outcome measures. This suggests that means-based aid is not simply subsidizing infra-marginal students in terms of ability – those who would not gain from the university experience – but actually acting to improve their outcomes at university. Turning to ability directly, we find that the benefit of aid is much higher for previously high achieving students. Students from the top half of the prior achievement distribution gain two to three times more from bursary aid than those from the bottom half of the distribution, in terms of test scores, completing the first year and obtaining a good degree. This suggests that there are some high ability students facing liquidity constraints, which bursary aid

[16] We do not provide estimates for relatively high/low income by institution as the estimation method relies on deviations in the outcome based on predictions from parental income within institution. Splitting the data within institution by parental income will improve the fit of the line and so reduce the variation that can be exploited.

is acting to relieve. Looking within institutions, we find only significant impact of aid on those in the top half of the prior achievement distribution. This has a further implication that university aid packages which target high achieving students may be more effective than those purely based on a means-test.

6. Conclusion

The majority of studies of the effectiveness of student aid focus on its effects on enrolment. This paper instead examines the causal effect of aid on the outcomes of students who have already enrolled in college. To do so we exploit changes and nonlinearities in university financial aid schedules as sources of variation, and find that unconditional financial aid in the form of an annual bursary increases students' likeliness of obtaining a good degree by 3.7 percentage points for each additional £1,000 of aid awarded. This positive effect is driven by both improvements in test scores and in degree completion rates. Given the unique institutional setting of bursary aid – that students are likely not aware of a university's scheme until a month before term starts and they are committed to attend– we are confident that these results relate purely to the intensive margin, rather than being driven through enrolment effects. Therefore the contribution of our paper is to provide rare evidence on the impact of aid on the intensive margin. These effects are comparable to those generated by Bettinger (2004), who finds a 4 percentage point effect on dropout for $1,000 of Pell Grants.

Our findings have several policy implications. Most importantly, our evidence suggests that aid matters even once students are enrolled in college, helping them to obtain better class degrees through improving persistence and course scores. Given that our form of aid is not used to pay towards college fees, it is likely that bursary aid is directly relieving liquidity constraints faced by students. Establishing that financial aid helps students to complete college, separate from any enrolment effects, has important consequences for how universities should allocate their resources a) to encourage enrolment and b) to improve persistence.

However, universities and policymakers should not simply assume that financial aid to all student types will be equally effective. A further major contribution of our paper is that we exploit the existence of multiple discontinuities in aid – this is unusual given that the literature typically exploits a single discontinuity or treatment. The marginal impact of financial aid is decreasing and from our fully parameterized estimation with a quadratic in aid, we find that aid continues to have a positive impact up to £1906.

There are two issues that policy makers need to bear in mind when designing the optimal aid package – liquidity and ability. First, the ideal aid package should encourage liquidity constrained students into college by lowering the cost of university to such a point where college becomes

affordable, and to provide enough financial support to enable them to succeed. Second, ideally aid should not simply subsidize infra-marginal students in terms of ability; those who may not have the necessary skills to succeed at college, but are drawn in due to the lower cost. Equally, it should not simply act as a transfer payment for ultra-marginal students; those who would attend college and do well regardless of the financial aid on offer.

Since our results indicate that aid receipt does have a positive impact on persistence and degree performance, this is evidence that aid is not simply subsidizing the infra-marginal student (based on ability); our results show that students receiving bursary aid persist further and achieve better outcomes than they would have done without the subsidy.

Our results also show that students from richer backgrounds gain less than those from poorer backgrounds. Therefore an efficient use of aid resources would be to attribute more to the lower income students and less to the high income students (who could be considered ultra-marginal in terms of liquidity). Whilst this is encouraging for proponents of means-tested aid, we should also consider that aid packages which are exclusively means-tested may not be the most efficient use of societal resources. Our results also show that high ability students benefit the most from aid, suggesting an important role for a merit component. This type of aid, that is dependent on merit and demonstrated need, is more common in the US in the form of scholarships, but less so in the UK.

What do these findings tell us about the effectiveness or otherwise of current aid packages at UK institutions? Universities give out, on average, £775 of bursary aid to each student, though with a large degree of variation around this, suggesting that many institutions could streamline their aid policies to improve efficiency. For example, many of the highly selective English institutions give out large aid packages to a small number of students (e.g. the poorest students at Imperial College, ranked 9th in the world[17], receive £6,000 per year in bursary aid). Given the decreasing returns to aid, such institutions should distribute their resources across more students, especially since their students are likely to be highly able, and therefore to gain the most.

Meanwhile, less selective institutions tend to give out smaller amounts of aid to larger numbers of students (e.g. Liverpool John Moores awards bursary aid of at least £400 to 65% of their students). Our evidence suggests they should instead give out more aid to the most able of their students.

This bursary aid policy came about as a result of increasing tuition fees in 2006, to alleviate concerns relating to participation of disadvantaged students, enforcing universities to distribute this additional fee income in the form of bursaries. This parallels the price discrimination that takes place

[17] Based on QS World University Rankings, 2016

at private non-profit institutions in the US, with the richer students effectively subsidizing the poor through higher fees. Given the long run labor market impacts of obtaining a good degree, this suggests this form of cross-subsidization is money well spent.

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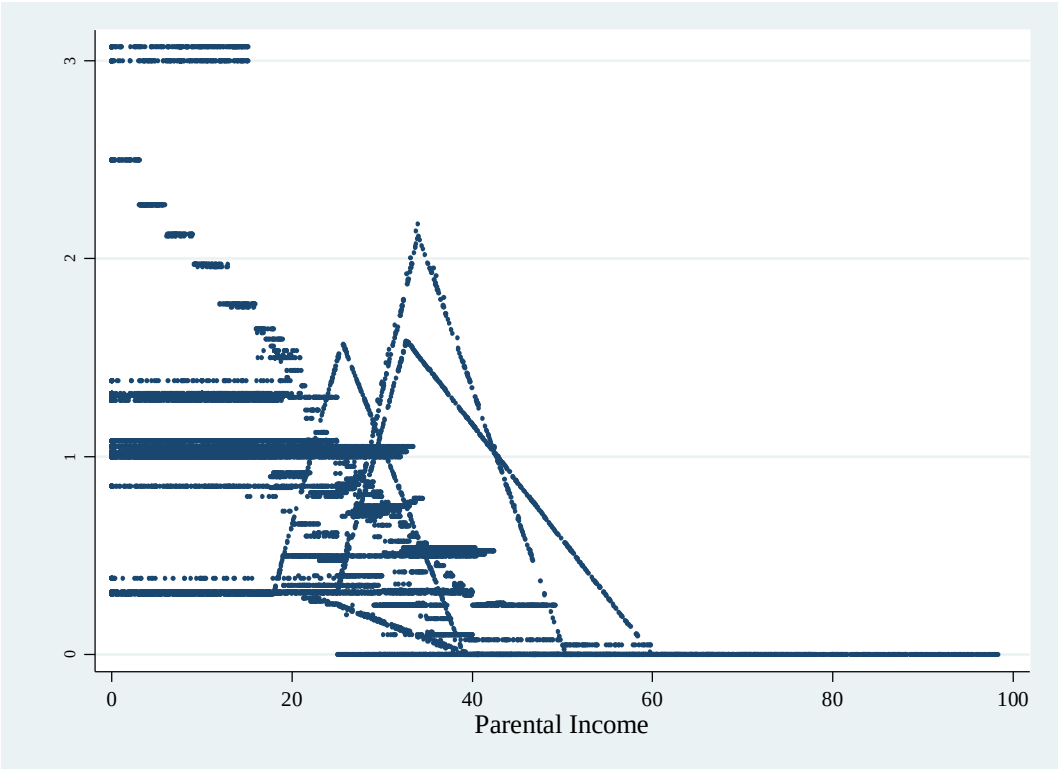
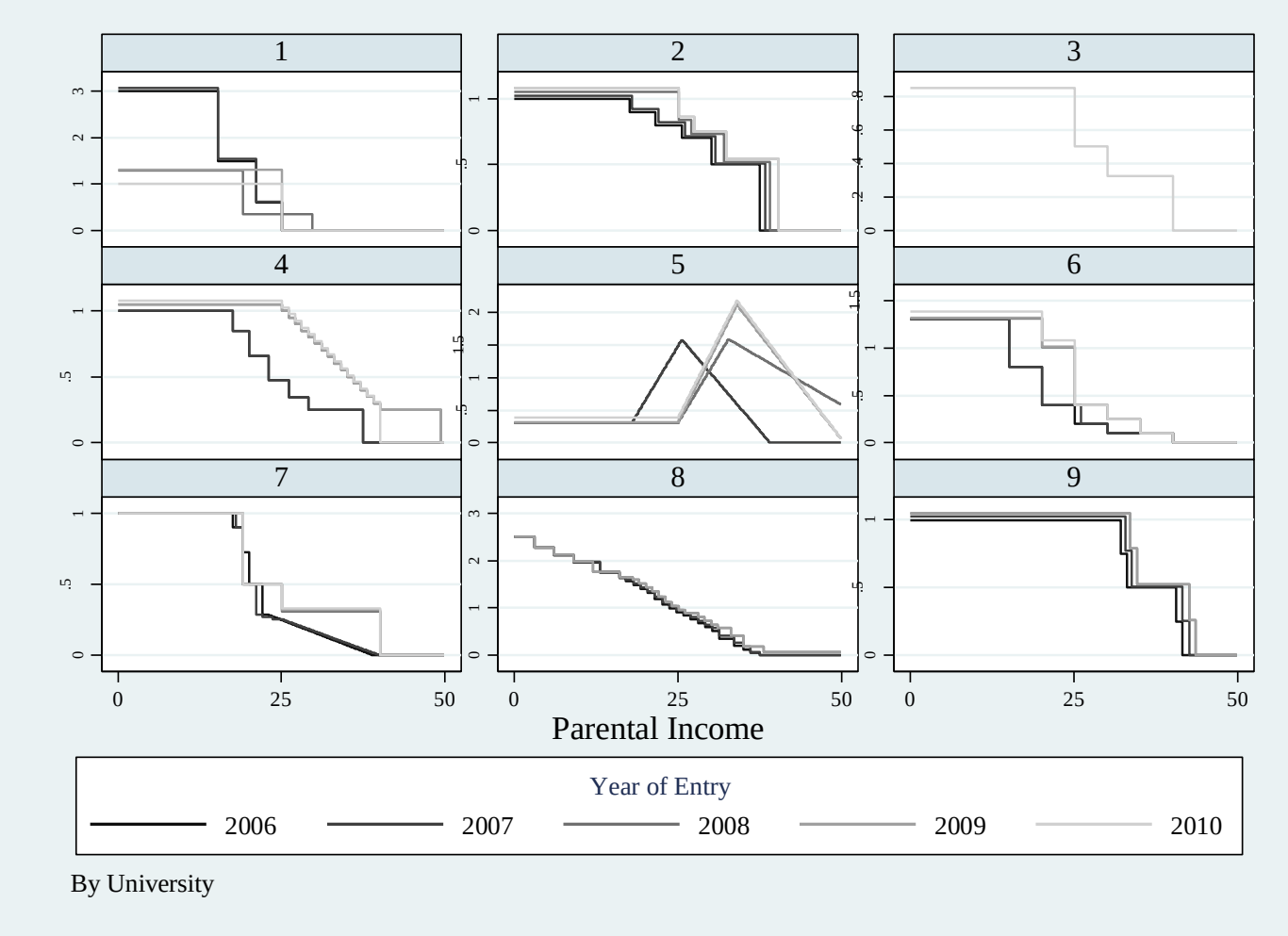
Figure 1: Eligible Bursary by parental income



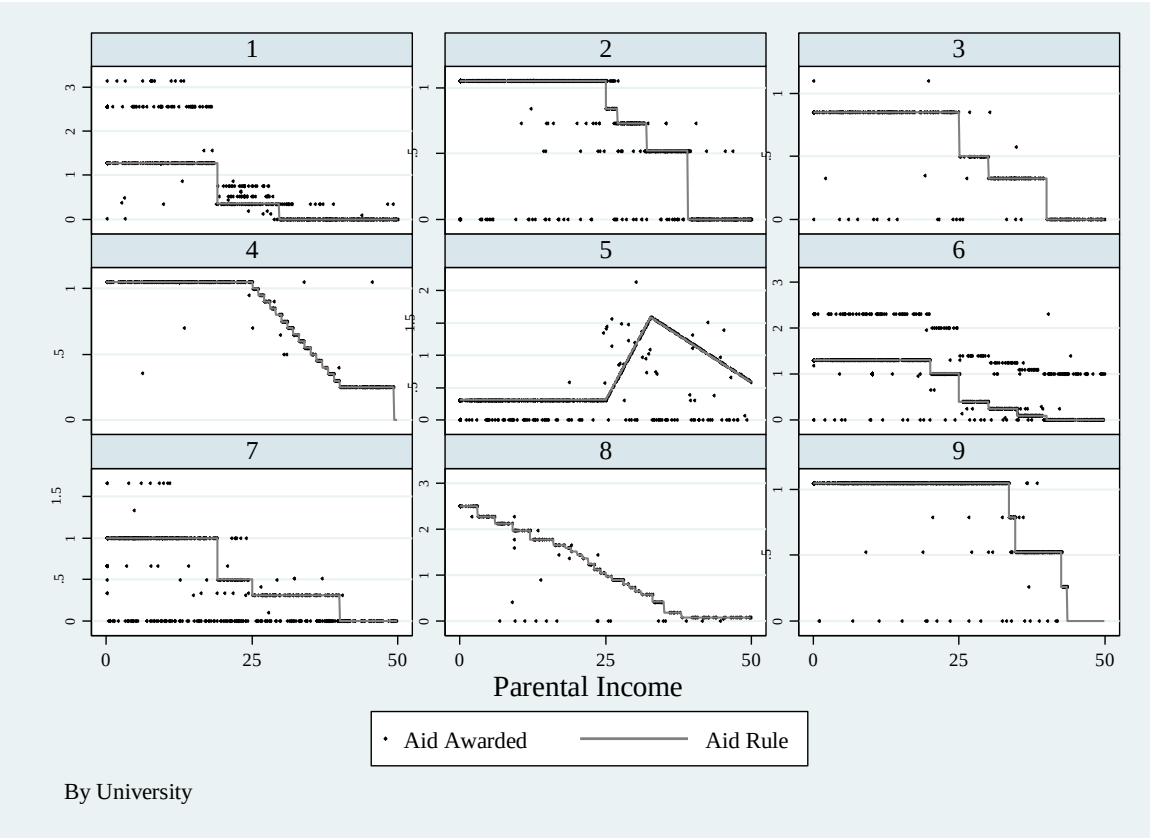
Notes: Each point represents the amount of bursary aid available for first year students at each university and entry cohort. Figures reported in nominal values. Source administrative data from the 9 universities.

Figure 2: Financial Aid Schedules at Universities over time



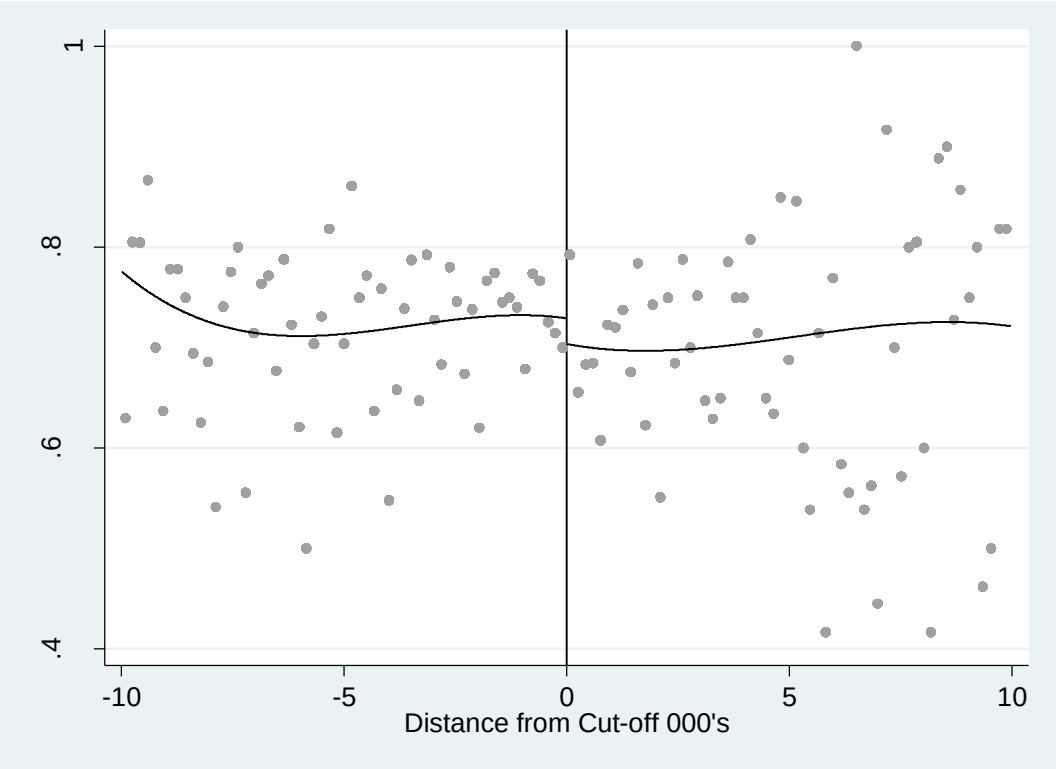
Notes: Represents the financial aid schedules for first year students for nine anonymous English universities for students entering in the years 2006 through to 2010. Figures reported in nominal values

Figure 3: University aid rules and compliance at universities in 2008



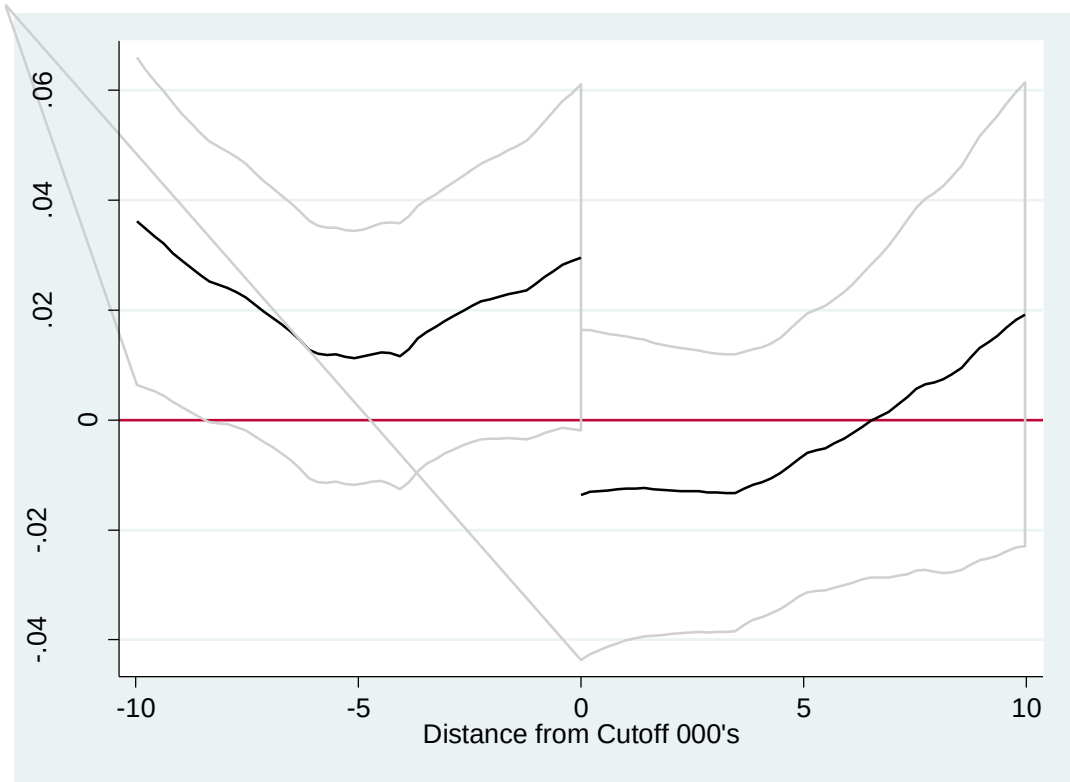
Notes: Figure 3 shows household income and bursary receipt for every first-year student in 2008 for each university. University 3 shows the compliance in 2010 rather than 2008, as that year of entry is not available for that university. The horizontal and vertical lines show the different bursary levels advertised by the university at each income level.

Figure 4: Good degree by distance from cut-off



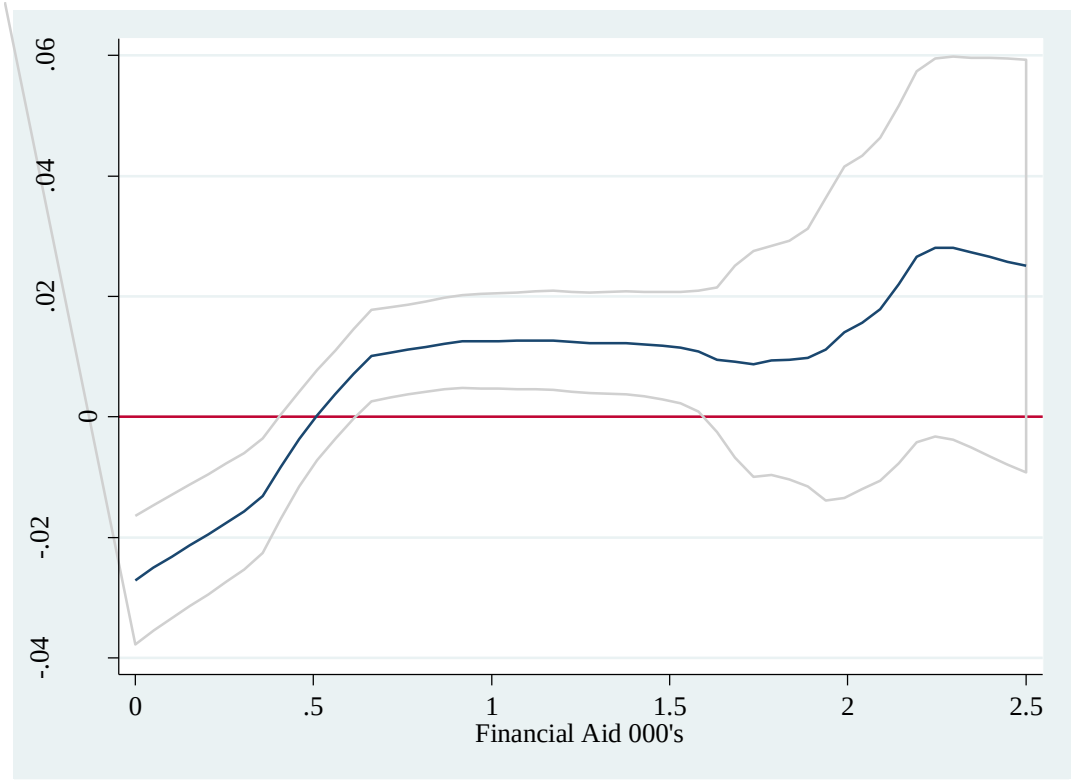
Notes: Figure 4 shows the average probability of a good degree, plotted according to distance from cut-off (for household incomes up to £10,000 above and £10,000 below the nearest cut-off) for discrete changes in bursary amounts over £100 (n=9093). The plotted line is line of best fit according to a 3rd order polynomial.

Figure 5: Residuals by distance from cut-off



Notes: Figure 5 plots the residuals from the main specification (equation 1) excluding the aid parameters, plotted according to distance from cut-off (for household incomes up to £10,000 above and £10,000 below the nearest cut-off) for discrete changes in bursary amounts over £100 (n=9093).

Figure 6: Residuals by financial aid amount



Notes: Figure 5 shows the residuals from the main specification (equation 1) excluding the aid parameters, (for household incomes up to £10,000 above and £10,000 below the nearest cut-off) for discrete changes in bursary amounts over £100 (n=9093).

Table 1: Our sample versus UK higher education institutions

		Sample	Remaining Higher Educational Institutions
Total Undergraduates		10107.78	12158.43
Proportion			
	Female	0.574	0.576
	Non-Disabled	0.89	0.894
Age			
	Under 21	0.419	0.373
	21-24	0.272	0.266
	25-29	0.113	0.120
	30+	0.196	0.240
	Age Unknown	0.000	0.001
Ethnicity			
	White	0.781	0.798
	Black	0.045	0.051
	Asian	0.088	0.080
	Other	0.046	0.037
Class of Degree			
	First Class	0.143	0.133
	Upper Second	0.545	0.438
	Lower Second	0.246	0.280
	Third - Pass	0.043	0.069
	Unclassified	0.024	0.078
	Dropout	0.095	0.109
Number of Universities		9	150

Notes: Source – HESA Statistical First Release 2009/10. Summary statistics for average of university characteristics. Undergraduate totals include full and part time students enrolled at the university. Proportion of student body by gender, ages, and disability is from all full and part time students enrolled at the university. Proportion of student body by ethnicity is from all full and part time UK-domiciled students enrolled at the university. Degree class, is from proportion of students who were awarded a first undergraduate degree. Dropout rate is the non-continuation rate of all full-time first degree entrants.

Table 2: Characteristics and student outcomes

	All Students		Balanced Panel of Students	
	(1)	(2)	(3)	(4)
	Mean	Std Dev	Mean	Std.dev
Household Income	£23,261	£19,476	£23,288	£19,253
Maintenance Grant	£2,059	£1,076	£2,035	£1,055
Bursary (eligible)	£759	£595	£787	£637
Bursary (awarded)	£753	£632	£775	£666
Entry Points	284.38	86.26	278.63	82.94
Male	0.44	0.5	0.43	0.49
White	0.78	0.42	0.78	0.41
Age on Entry	20.13	4.84	20.05	4.79
Complete				
1st Year	0.95	0.22	0.95	0.21
2nd Year	0.92	0.27	0.92	0.27
3rd Year	0.89	0.31	0.9	0.3
Dropout				
1st Year	0.05	0.22	0.05	0.21
2nd Year	0.03	0.17	0.03	0.18
3rd Year	0.01	0.12	0.02	0.14
Standardised Scores Yr1				
1st Year	0.00	1.00	0.03	0.96
2nd Year	0.00	1.00	0.03	0.96
3rd Year	0.00	1.00	0.04	0.95
"Good Degree"	0.60	0.49	0.63	0.48
N	35,879		22,770	

Notes: All Students consists of students from the nine universities undertaking a degree for the years we have available, including continuing students. Students dropping out are recorded as not obtaining a good degree (Good Degree=0). Those continuing and but not yet completed have no measure of good degree. Balanced Panel of Students consists of the subsample of students that theoretically could have completed their course given their entry date, and the data we have available.

Table 3: Impact of financial aid in form of bursary on probability of obtaining a good degree

P(Good Degree)	(1)	(2)	(3)	(4)	(5)	(6)
Panel A						
1st Year Bursary Aid	0.012	0.090***	0.043**	0.034**	0.037***	0.035***
Awarded	(0.017)	(0.018)	(0.016)	(0.013)	(0.012)	(0.011)
Panel B						
1st Year Bursary	-0.039	0.136***	0.124***	0.142***	0.140***	0.128***
Aid	(0.038)	(0.031)	(0.023)	(0.024)	(0.023)	(0.023)
1st Year Bursary	0.022*	-0.017*	-0.030***	-0.041***	-0.039***	-0.037***
Aid squared	(0.011)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)
Marginal effect	-0.005	0.110***	0.077***	0.078***	0.079***	0.071***
at mean	(0.024)	(0.019)	(0.013)	(0.013)	(0.013)	(0.012)
R-squared	0.001	0.024	0.120	0.133	0.133	0.144
Panel C – Reduced form Marginal						
effects 1st	-0.048**	0.062**	0.044**	0.032**	0.031***	0.032***
Year Bursary Rules	(0.020)	(0.030)	(0.016)	(0.012)	(0.010)	(0.010)
Panel D – Instrumented						
1st Year Bursary Aid	-0.137***	0.056	0.058**	0.062***	0.059***	0.061***
	(0.037)	(0.050)	(0.029)	(0.023)	(0.020)	(0.019)
1st Year Bursary Aid	0.052***	0.007	-0.011	-0.017***	-0.015**	-0.016***
Squared	(0.014)	(0.015)	(0.010)	(0.007)	(0.006)	(0.006)
Marginal Effects 1st Year	-0.056**	0.066**	0.042**	0.035***	0.036***	0.037***
Bursary Aid	(0.022)	(0.030)	(0.016)	(0.013)	(0.011)	(0.011)
R-Squared	0.004	0.023	0.119	0.132	0.132	0.143
Sheas's Adj-P R^2 Bursary Aid	0.756	0.591	0.530	0.490	0.475	0.472
Sheas's Adj-P R^2 Bursary Aid^2	0.796	0.673	0.611	0.567	0.552	0.548
Parental Income		✓	✓	✓	✓	✓
Student Characteristics			✓	✓	✓	✓
University Effects				✓	✓	
Year Effects					✓	
University*Year Effects						✓

Notes: Coefficients in panel C show marginal effect at mean bursary amount. 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*year level.* p < 0.1. ** p < 0.05. *** p < 0.01, N=22,770 for all regressions

Table 4: Impact of financial aid in form of bursary on probability of completion

P(Complete)	Complete 1st year	Complete 2nd year	Complete 3rd year	Good degree
	(1)	(2)	(3)	(4)
Panel A				
1st year Bursary Aid	0.073***	0.085***	0.087***	0.071***
Awarded	(0.018)	(0.017)	(0.017)	(0.012)
Panel B				
IV- 1st year Bursary	0.024**	0.031**	0.033**	0.061***
Aid	(0.011)	(0.014)	(0.016)	(0.019)
IV- 1st year Bursary	-0.007**	-0.009**	-0.009*	-0.016***
Aid squared	(0.003)	(0.004)	(0.005)	(0.006)
Marginal effect	0.014**	0.016**	0.019**	0.037***
at mean	(0.006)	(0.008)	(0.009)	(0.011)
R-Squared	0.127	0.114	0.115	0.143
Parental Income	✓	✓	✓	✓
Student Characteristics	✓	✓	✓	✓
University*Year Effects	✓	✓	✓	✓

Notes: Coefficients presented are of marginal effects at mean bursary amount. Sample consists only of those students whose final outcome can be observed. Standard errors are in parenthesis, and are clustered at institution*year level.* $p < 0.1$. ** $p < 0.05$. *** $p < 0.01$. For all regressions, N=22,770

Table 5: Impact of financial aid on course scores

P(Course Scores)	Course scores 1st year		Course scores 2nd year		Course scores 3rd year		Good degree
	(1)		(2)		(3)		(4)
Panel A							
1st year Bursary Aid	0.093***		0.056**		0.062***		0.071***
awarded	(0.023)		(0.020)		(0.018)		(0.012)
Panel B							
IV- 1st year Bursary	0.123***		0.079***		0.046		0.061***
Aid	(0.026)		(0.030)		(0.040)		(0.019)
IV- 1st year Bursary	-0.036***		-0.023**		-0.010		-0.016***
Aid squared	(0.008)		(0.011)		(0.013)		(0.006)
Marginal effect at mean	0.064***		0.041***		0.030		0.037***
	(0.015)		(0.015)		(0.021)		(0.011)
R-Squared	0.085		0.096		0.085		0.136
N	17,060		16,218		14,623		22,770
Panel C							
Banded estimates							
Marginal effect at mean	0.043*	0.102***	0.036*	0.045*	0.018	0.091**	
	(0.023)	(0.033)	(0.019)	(0.025)	(0.027)	(0.045)	
N	17,912		17,912		17,624		
Parental Income	✓		✓		✓		✓
Student Characteristics	✓		✓		✓		✓
University*Year Effects	✓		✓		✓		✓

Notes: Coefficients presented are of marginal effects at mean bursary amount. Sample consists only of those students whose final outcome can be observed. Standard errors are in parenthesis, and are clustered at institution*year level.* $p < 0.1$. ** $p < 0.05$. *** $p < 0.01$. Some courses do not have module scores, hence we have not been able to impute bounds for these courses. In addition, university 3 does not have course scores for creative arts courses in year 3, hence difference in sample sizes for year 3.

Table 6: Robustness Checks

	IV Financial Aid Rules		
	Complete 1st Year	Course Scores 1st Year	Good Degree
Specification	(1)	(2)	(3)
Main Specification	0.014**	0.064***	0.037***
	(0.006)	(0.015)	(0.011)
N	*22,770*	*17,060*	*22,770*
Include Continuing Students	0.011**	0.046***	NA
	(0.005)	(0.013)	
N	*35,879*	*26,290*	
Exclude Outlying Entry Score Universities	0.019**	0.062***	0.051***
(1, 2, 8)	(0.009)	(0.021)	(0.018)
N	*13,485*	*9,695*	*13,485*

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. Standard errors are in parenthesis, and are clustered at institution*year level. * p < 0.1. ** p < 0.05. *** p < 0.01

Table 7: Pre determined Variables

	Std Prior Test Scores	Male	Age on Entry	White	Subject	Maintenance Grant
Specification	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Balanced Sample						
1st Year Bursary Aid	-0.001	0.005	0.472	-0.045	0.075	0.320
	(0.065)	(0.024)	(0.576)	(0.039)	(0.301)	(0.269)
1st Year Bursary Aid Squared	-0.001	-0.009	-0.271	0.018	-0.020	-0.058
	(0.020)	(0.008)	(0.189)	(0.012)	(0.103)	(0.073)
Panel B: Continuing Students Sample						
1st Year Bursary Aid	0.062	0.009	0.185	-0.012	0.370	0.191
	(0.057)	(0.014)	(0.247)	(0.019)	(0.248)	(0.191)
1st Year Bursary Aid Squared	-0.005	-0.006	-0.135	0.005	-0.146	-0.039
	(0.020)	(0.005)	(0.102)	(0.008)	(0.104)	(0.024)

Notes: Balanced Sample contains 22,770 observations, and includes students that could have completed their degree. Continuing Students Sample contains 35,879 observations and includes all students who have yet to complete their degree. For the purposes of brevity and for this table only the twelve subject areas have been combined

into one index. This index ranges from 1 to 12 with the hard sciences taking the lower values, and arts taking the higher values. Standard errors are in parenthesis, and are clustered at institution*year level. * p < 0.1. ** p < 0.05. *** p < 0.01

Table 8: Alternative polynomial specifications

	IV Financial Aid Rules		
Specification	Complete 1st Year (1)	Course Scores 1st Year (2)	Good Degree (3)
$Income$	0.014**	0.075***	0.037***
	(0.006)	(0.018)	(0.012)
$+Income^2$	0.014**	0.073***	0.038***
	(0.006)	(0.016)	(0.011)
$+Income^3$	0.014**	0.064***	0.037***
	(0.006)	(0.015)	(0.011)
$+Income^4$	0.013**	0.051***	0.033***
	(0.006)	(0.019)	(0.010)
$+Income^5$	0.014**	0.055***	0.034***
	(0.007)	(0.019)	(0.011)
	22,770	17,060	22,770

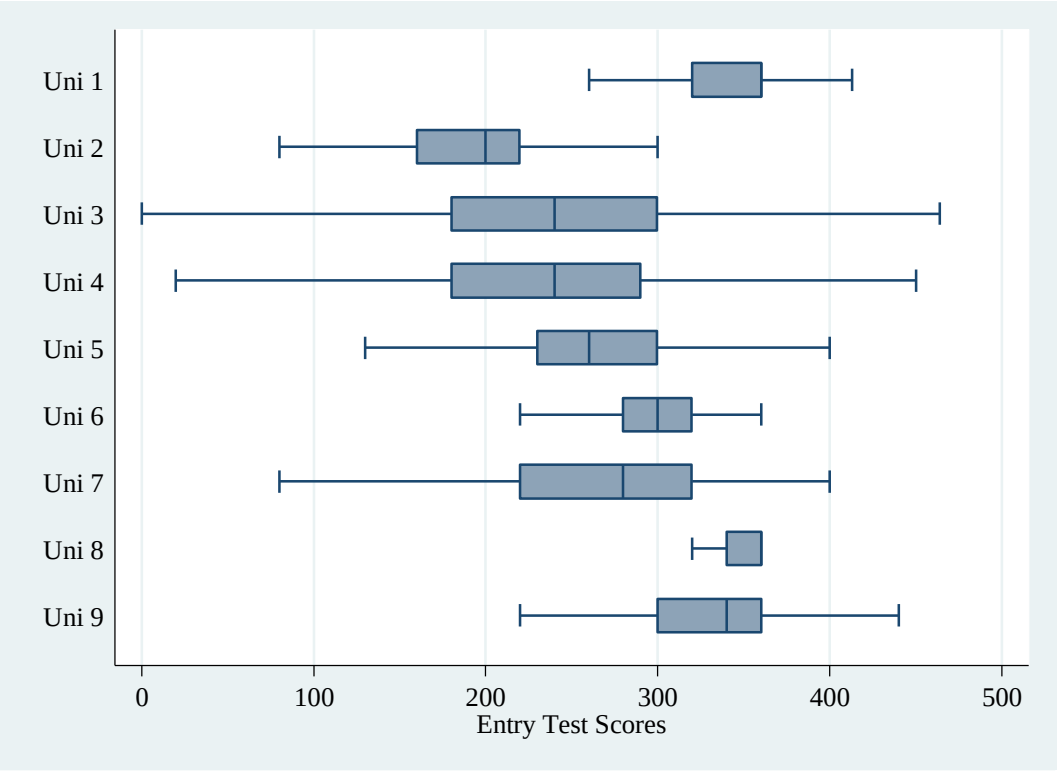
Notes: Notes: Coefficients presented are of marginal effects at mean bursary amount. Sample consists only of those students whose final outcome can be observed. Standard errors are in parenthesis, and are clustered at institution*year level.* p < 0.1. ** p < 0.05. *** p < 0.01

Table 9: Heterogeneity

Outcome	All	Male	Female	Enter Young (Age<20)	Enter Old (20>=Age <30)	Poor	Rich	Tariff Low	Tariff High	Relatively Low Tariff	Relatively High Tariff
Good Degree	0.031***	0.046**	0.041**	0.051***	-0.026	0.207**	0.065**	0.031*	0.092***	0.021	0.072***
	(0.010)	(0.022)	(0.019)	(0.016)	(0.023)	(0.096)	(0.028)	(0.016)	(0.019)	(0.013)	(0.016)
Test Scores Yr1	0.057***	0.070**	0.085***	0.089***	0.010	0.316*	0.082	0.051***	0.121***	0.045	0.071**
	(0.016)	(0.032)	(0.027)	(0.025)	(0.046)	(0.171)	(0.057)	(0.018)	(0.039)	(0.041)	(0.034)
Complete Yr1	0.014**	0.020***	0.014	0.018***	-0.021	0.070*	0.014	0.013**	0.033***	0.008	0.033***
	(0.006)	(0.007)	(0.010)	(0.007)	(0.019)	(0.042)	(0.010)	(0.006)	(0.007)	(0.006)	(0.005)
Obs	22,770	9,740	13,030	17,150	5,620	11,385	11,385	9,795	7,733	7,035	10,493

Notes: Notes: Coefficients presented are of marginal effects at mean bursary amount. Sample consists only of those students whose final outcome can be observed. (Relatively) Low Tariff defined by any student under the 50th entry test score percentile (within their institution). The 5242 students with no recorded entry test scores are excluded from the test score heterogeneity. Standard errors are in parenthesis, and are clustered at institution*year level.* $p < 0.1$. ** $p < 0.05$. *** $p < 0.01$.

Appendix A1: 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 9 universities.