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Abstract

The majority of undergraduate university applications in the state of New South Wales – Australia's largest state – are processed by a clearinghouse, the Universities Admissions Centre (UAC). Applicants submit an ordered list of degree preferences to UAC which applies a matching algorithm to allocate university places to eligible applicants. The algorithm incorporates the possibility of a type of "early action" through which applicants receive guaranteed enrolments. Applicants receive advice on how to construct their degree preference list from multiple sources (including individual universities). This advice is often confusing, inconsistent with official UAC advice or simply misleading. To evaluate the policy implications of this design choice, we run a large sample (832 observations) experiment with experienced participants in a choice environment that mimics the UAC application process and in which truth telling is a dominant strategy. We vary the advice received across treatments: no advice, UAC advice only, (inaccurate) university advice only, and both UAC and university advice together. Overall, 75.5% of participants fail to use the dominant strategy. High rates of

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applicant manipulation persist even when applicants are provided with accurate UAC advice. We find that students who attend non-selective government schools are more prone to use strictly dominated strategies than those who attend academically selective government schools and private schools.

1. Introduction

"A lie can travel halfway around the world while the truth is still putting on its shoes"
- Mark Twain (?)[1]

Each year, over 40,000 graduating high school students in Australia's largest state of New South Wales (NSW) apply to study their preferred degree at their preferred university.

In NSW, university admission is a major annual event that involves multiple stakeholders. Students compete for a place in their most desired degree, from among those degrees for which they are eligible. Universities aspire to admit the most accomplished students, while also enrolling as many students as they can.[2] To solve this problem, the majority of university applications are processed by a clearinghouse, the Universities Admissions Centre (UAC). Applicants first submit an ordered preference list of degrees for which they wish to be considered.[3] To generate offers to students, UAC then uses a matching algorithm that accounts for a student's individual assessment scores and the University-determined, degree-specific, entry cut-off scores.

The algorithm used by UAC sequentially checks each applicant's eligibility for a degree starting with her first choice. It is therefore reminiscent of the Boston mechanism widely used for school choice in the U.S. (Abdulkadiroglu et al, 2005; Abdulkadiroglu et al, 2006) and college admissions in China (Chen and Kesten, 2017) among other places. However, the absence of formal capacity constraints (on university enrolments) makes this Australian context a unique instance in which the outcome of the algorithm also coincides with that of the celebrated Deferred Acceptance (DA) algorithm of Gale and Shapley (1962). Due to this

[1] Or perhaps Jonathan Swift, see https://www.nytimes.com/2017/04/26/books/famous-misquotations.html.
[2] In contrast with the US, student fees comprise the bulk of university revenue in Australia.
[3] Some applicants, most notably international students, apply direct to universities bypassing the UAC system. This paper relates only to those applicants – the vast majority of domestic school leavers – who apply via UAC.

equivalence, the UAC algorithm does not inherit the strategic vulnerability of the Boston algorithm. Consequently, students are still able to construct their preferred degree list in a manner that is consistent with their true preferences.[4]

While the UAC admissions system appears similar to a typical college admissions problem (see, e.g., Roth and Sotomayor, 1991 and Balinski and Sönmez, 1998), universities in NSW can influence student applications through an additional channel. To limit the uncertainty faced by applicants,[5] many universities often grant applicants "guaranteed entry" options.[6] These schemes represent a university's commitment to an individualised entry requirement for a particular degree, subject to the candidate's achievement of a certain score. This innovative feature of the UAC system can be viewed as the centralized or algorithmic embodiment of "early decision" schemes used by over two-thirds of top colleges in the US (see, e.g., Avery, Fairbanks, and Zeckhauser, 2004) that admit students through a decentralized system.[7] Indeed, we are not aware of any other centralized college admissions system that has this type of feature. Under the current UAC algorithm, if an applicant includes a guaranteed entry degree in her preference list, this implies that she will not be considered for any degree that she has listed lower on her list provided that she attains the pre-announced entry score. In this sense, guaranteed entry options can be also viewed similarly to the notion of 'district school priority' commonly observed in the context of school choice (see, e.g., Chen and Sönmez, 2006; Calsamiglia, Haeringer and Klijn, 2010).[8]

While guaranteed entry options help reduce uncertainty at the time of preference submission, they could be used sub-optimally by applicants. Specifically, when the guarantee relates to some degree other than an applicant's most preferred, she may still list a guaranteed entry

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[4] To be precise, since applicants can only list up to five degrees, it is in the best interest of each applicant to truthfully rank the degrees she *chooses* to include in her preference list. Nevertheless, due to the length constraint, the UAC mechanism is still not fully strategy-proof. This means students may need to make trade-offs in deciding which degrees to apply for (see Haeringer and Klijn, 2009). The majority of matching programs using DA sacrifice strategy-proofness in a similar manner by restricting preference lengths.

[5] Ordinarily, at the time of preference submission, participants know neither their selection scores nor the minimum entry scores of degrees in the *current* year.

[6] A more comprehensive description of Guaranteed Entry schemes is provided in Section 2.4. Similar schemes are also used by prestigious universities in other states of Australia such as Victoria and Queensland.

[7] In the US, an Early Decision program represents a mutual commitment to enrol between a student and a college if the student meets the specific admissions criterion laid out in the program. When a student includes a guaranteed entry school in her preference list, she may still be eligible for colleges she ranks higher up.

[8] In school choice, however, whether or not to grant district school priority to a student does not involve any strategic decision on the part of schools. Such priorities are mandated by the school district.

degree above one which, while not guaranteed, she nevertheless prefers and may, in fact, be eligible for. Although such strategies are clearly dominated by truth-telling, the informational environment the applicants are drawn into appear to play an important role in these decisions.

Prior to the offer process, applicants often seek advice on how best to list their degree preferences. This advice may be obtained from UAC, individual universities or other parties such as school careers advisors or parents. The standard advice UAC provides students is as follows:

"List your 'dream preference' at number one but follow that with realistic preferences. At the bottom of the preference list you should include one or two 'safe' options to ensure that you get an offer" (UAC, 2018).

On the other hand, universities often provide advice that conflicts with that of UAC:

"To be offered a place in a guaranteed entry course[9]*, list the course as your first preference when you apply"* (Major University A, 2018).

"*The only way we can guarantee you a place is if you have the guaranteed entry (selection rank) and you have the degree listed as your highest eligible preference.*" (Major University B, 2018)

The general manager of Marketing and Engagement at UAC expresses the difficulty of dealing with students who face such mixed advice:
"We get hundreds, if not thousands, of applicants every year who contact us because they are unsure about how to order their preferences. We tell them that they don't need to have their guaranteed entry degree as their first preference unless it really is the one they want the most, but they often say they will put it first anyway, just to be on the safe side. It's frustrating in a way, but you can also see where they're coming from. The stakes for them are high. They are far more concerned about missing out on an offer than they are about using the system to their own advantage." (Kim Paino, General Manager, Marketing and Engagement, UAC)[10]

[9] In Australia the word 'course' is synonymous to and often used instead of 'degree'.
[10] Personal communication with Kim Paino.

We examine the implications of the institutional features of the university placement system in NSW – namely, restricted lists, guaranteed entry schemes and advice provision – on applicant behaviour. To do this we conduct an online experiment using a sample from a recent UAC applicant cohort (2018-19), who completed Year 12 (12th Grade) in NSW. We design a task that simulates the UAC application process for a choice environment in which truth telling is the unique optimal way to order degree preferences. Using a randomised treatment, we examine the effects of advice given to applicants by UAC and a university on how best to construct their ordered degree preference list.

In our design, participants are able to apply to up to 5 degrees from a choice set of 6 degrees. They are informed that they have guaranteed entry into the degree with the fifth highest payoff. Since truth telling is the unique optimal strategy, this degree should not be listed higher than the fifth position. Accordingly, we refer to participants who list this degree higher than fifth as exhibiting *Guaranteed Entry Bias* (*GEB*). We also randomly assign participants to one of four treatment groups. All groups receive a common set of instructions on what they need to do in order to submit their degree preference lists. The 'No Advice' group receives only these instructions. The 'UAC Advice' group additionally receives the accurate UAC advice quoted above while the 'University Advice' group receives the inaccurate university advice quoted above. The fourth group receives *both* the UAC advice and the university advice.

Despite truth telling being the unique optimal strategy, 75.5% of participants across treatments manipulate in one way or another. We refer to participants who fail to tell the truth as exhibiting *Sub-optimal Ordering*. Moreover, 55.8% of participants exhibit *GEB*. This rate is higher than that for another dominated strategy – *Including Degree 6* – that involves participants including the least preferred degree (Degree 6) in their list, despite it being dominated by all the other five degrees including the guaranteed entry degree. These results suggest a widespread misunderstanding of the UAC application process.

Rates of *Sub-optimal Ordering* and *GEB* are high across all advice treatment groups and the No Advice group. However, these rates are statistically significantly higher for the University Advice and Combined Advice groups. The effect of the university advice is not surprising, as the advice suggests applicants place the guaranteed entry degree first. However, it is interesting that when this advice is combined with the UAC advice, which performs significantly better on its own, the combined effect is almost indistinguishable from the university advice effect. This suggests that accurate, albeit somewhat complicated, advice may fail to mitigate the impact of inaccurate (but straightforward) advice.

We also examine the effects of demographic factors and advice. We find statistically significant differences based on school type and gender, controlling for advice treatment and other factors. Participants who attended non-selective (i.e. comprehensive) government schools exhibit the highest rates of *Sub-optimal Ordering*. Participants who attended selective government schools exhibit the lowest rates. These results align with a series of studies[11] finding higher rates of sub-optimal behaviour for lower ability applicants. However, there is a lower rate of *GEB* for private school students, suggesting that greater access to (accurate) advice may also play a role. Further, we find that women exhibit statistically significantly higher rates of *Including Degree 6* compared to men. These results suggest that particular demographic groups may be more affected by misunderstanding than others.

These results are significant from a policy perspective. They point to potentially large welfare losses as many applicants may be missing out on studying degrees that they most want to study. Perhaps even more concerning is the fact that applicants from certain demographic groups may be disproportionately susceptible to these adverse consequences.

Relation to Literature

This paper contributes to the general literature on matching problems as well as to the growing literature concerning experimental evaluations of applicant behaviour in matching processes (Roth and Sotomayor, 1990**;** Abdulkadiroglu and Sönmez, 2003; Chen and Sönmez 2006). Our research is novel in a number of ways. First of all and in contrast to the vast majority of experimental matching studies,[12] we provide an ex-post evaluation run in the field with experienced participants. To our knowledge, we are the first to report a novel clearinghouse, which embeds guaranteed enrolment possibilities into a centralized matching process akin to the popular Early Decision programs used in decentralized college admissions. Ours is the first study to use a field experiment to concurrently investigate: (i) applicant understanding of a

[11] Romm and Shorrer (2016), Shorrer and Sóvágó (2018), Rees-Jones and Skowronek (2018) and Basteck and Mantovani (2018)

[12] As far as we know, only Rees-Jones and Skowronek (2018) used a similar methodology albeit with no experimental treatments other than what constitutes a baseline.

mechanism that is not strategy-proof *per se*[13] and where applicants are not advised on clear strategies to follow; (ii) the effects of advice given by market makers; and (iii) rates of district school bias, *GEB* here. We offer insights into the behaviour of participants with experience in a high stakes matching mechanism and show how, in practice, they fail to understand the incentives of such a mechanism to an even greater extent than shown in laboratory experiments. Most notably, we demonstrate through experienced participants from the field, that even with a simple and strategy-proof mechanism, applicants are prone to being led into error by incorrect advice from market actors, and that correct advice from other market operators doesn't help rectify this situation.

Much of the theoretical literature discusses the trade-off among the desirable properties of strategy-proofness, stability, and efficiency. Strategy-proofness makes it easier to advise applicants and is often believed to level the playing field (Pathak and Sönmez, 2008), while stability and Pareto Efficiency are incompatible (see Roth, 1982; Abdulkadiroglu and Sönmez, 2003; Abdulkadiroglu, Pathak and Roth, 2009; Kesten 2010).

Owing much to its stability and strategic immunity, DA has been adopted for school choice in cities such as New York and Boston (see Abdulkadiroglu, Pathak and Roth, 2005; Abdulkadiroglu et al, 2006) and has been in use in several entry-level labor markets including the National Resident Matching Program (NRMP) that annually matches approximately 30,000 graduating medical doctors to residency positions at U.S. hospitals (Roth and Peranson, 1999).

Despite the appeal of strategy-proofness, the literature suggests applicants may still fail to tell the truth in strategy-proof environments, in both laboratory experiments[14] and in the field[15]. Chen and Sönmez (2006) run a school choice laboratory experiment in which they test two strategy-proof mechanisms, Top Trading Cycles (TTC) and DA. They observe that 53% and 36% of applicants manipulated under the TTC and DA mechanisms, respectively.

[13] As already mentioned, the UAC mechanism is not strategy-proof since applicants can only include a maximum of five degrees in their ordered lists. However, truth-telling is the unique optimal strategy in the experimental choice environment. Using this design allows us to infer applicant misunderstanding where they fail to tell the truth.
[14] See, for example, Braun et al (2014), Featherstone and Niederle (2016), Guillen and Hakimov (2017), Ding and Schotter (2017), Basteck and Mantovani (2018), Li (2017) and Koutout et al. (2018).
[15] See, for example, Artemov, Che and He (2017), Guillen and Hakimov (2018), Hassidim, Romm and Shorrer (2018), Rees-Jones (2018) and Shorrer and Sóvágó (2018). A number of these studies were helpfully collated by experiment type in Rees-Jones, Shorrer and Tergiman (2019).

Rees-Jones and Skowronek (2018) run a field experiment in which former applicants participate in a simulation of the DA in the NRMP application process. The NRMP presents no incentive to manipulate, involves extremely high stakes, applicants construct relatively short preference lists and they are clearly advised that truth telling is an optimal strategy. Nevertheless, Rees-Jones and Skowronek (2018) find a 23% manipulation rate. This suggests that factors beyond advice may affect manipulation rates. Specifically, they find that manipulation may be correlated with academic ability or gender. Our paper is the second, after Rees-Jones and Skowronek (2018), to examine former applicant behaviour in a controlled setting.

A less explored question is how to explain manipulation. When reviewing the early literature in this area, Pathak (2016) draws a connection between manipulation and the extent to which applicants trust or act upon the advice given by mechanism operators. He attributes the high rates of manipulation in Chen and Sönmez (2006) to the descriptions of the mechanisms neglecting to state when reporting preferences truthfully is optimal. This is consistent with Guillen and Hakimov (2018) who find higher rates of manipulation when a mechanism is described, as opposed to when the optimal strategy is described, for example, that truth telling is optimal. The intuition behind this result, is that simply explaining to applicants how a mechanism works may not help them know how to act. In contrast, telling them how they should act, for example, that they should tell the truth, is more effective even if they do not know how the mechanism works. Similarly, Koutout et al. (2018) find that truth-telling rates under DA increase when participants are advised that truth-telling is optimal in a school choice laboratory experiment.

The remainder of this paper proceeds as follows. Section 2 provides an overview of the institutional context of the university application process in NSW, including the UAC mechanism. Section 3 provides an overview of the underlying theory. Section 4 describes the experimental design. Section 5 outlines the results of the experiment and includes an interpretation of these results. Section 6 outlines policy implications and avenues for further research. Section 7 concludes.

2. Institutional Context

UAC processes applications for the majority of undergraduate university degrees in NSW. Applicants submit an ordered list of up to five degrees that they wish to be considered for. Based on these lists, UAC runs an algorithm to generate degree offers on behalf of universities.

UAC makes offers across multiple offer rounds spread over several months. However, the majority of offers are made in two offer rounds, the first in late December, and the second in early January known as the 'main rounds' (UAC, 2019c). These are the first two offer rounds after applicants receive their final results. The matching task in this study simulates one of these main rounds. Offers are also made prior to the main rounds but these mainly relate to alternative access schemes established by individual universities and are beyond the scope of this study.

Applicants receive a maximum of one offer per round which they can accept or reject. Applicants can receive offers in multiple rounds. However, degree entry requirements can vary between rounds. As such, applicants are best served by receiving an offer to their most preferred degree as early as possible.

The UAC Mechanism uses three pieces of data: the degree preference lists submitted by applicants, each applicant's selection rank for a degree and a university's Lowest Selection Rank for a degree.

An applicant's selection rank is the sum of her Australian Tertiary Admissions Rank (ATAR) and any 'adjustment factors' she is eligible for. The ATAR is a standardised performance ranking calculated on the basis of assessment results in the last year of high school.[16] It is designed to allow universities to compare applicants on the basis of academic achievement. Adjustment factors can increase an applicant's selection rank above their ATAR. The application and calculation of adjustment factors is not standardised, but instead is determined

[16] These assessment results reflect a student's performance in both in-school assessments and external examinations.

by universities. It may even differ across different degrees at the same university. This means an applicant may have a different selection rank for every degree that she applies for.[17]

Each university submits to UAC a Lowest Selection Rank (LSR) for each degree. These ATAR cut-offs, otherwise known as 'Selection Rank Cut-offs', are updated for each offer round in which a university makes offers for a given degree.

UAC's offer algorithm is a recursive process that runs as follows:

Step 1: Consider the applicant's first listed degree. Is their selection rank above the selection rank cut-off? If yes, make an offer and stop. If no, proceed to the next step.

….

Step k: Repeat Step 1 for the applicant's k-th listed degree.
If no offer is made after considering the last listed degree, then no offer is made.

Applicants are ordinarily not informed of the Selection Rank cut-off that universities submit to UAC. Instead, they only know the Lowest Selection Rank from the previous year and are told that this is merely a guide (UAC, 2019b).

In an effort to overcome the uncertainty applicants face – not just with respect to the current year's Selection Rank cut-offs for each degree (i.e. the LSRs), but also with respect to the applicant's own yet-to-be-determined selection rank – some universities have instituted 'guaranteed entry' schemes. While these have different names for marketing reasons, they all operate in a similar way. For certain degrees, universities publish a selection rank which, if achieved by an applicant listing the degree high enough in their list, 'guarantees' them an offer of entry to that degree. An applicant then knows with certainty that they are eligible to receive an offer to that degree if their ATAR (plus any adjustment factors) exceeds the guaranteed entry cut-off.

[17] Some common reasons for the application of adjustment factors include experiencing disadvantage during the last two years of school or notable performance in subjects related to the degree applied for. The sum of adjustment factors is normally capped at 5 or 10 points. The extent to which applicants are advised of their eligibility for, as well as the size of, adjustments is also not uniform. In some cases, applicants are informed if they are eligible for an adjustment but not its size. Alternatively, adjustment factor criteria and sizes are sometimes displayed on university websites, allowing applicants to calculate them for themselves.

These schemes are clearly advantageous to applicants who are granted guaranteed entry to their most preferred degree. They should then simply list that degree first in their ordered list and accept the offer generated. However, how to compose an ordered list may be less obvious if an applicant is granted guaranteed entry to a degree that is not her most preferred while she remains uncertain as to whether she will qualify for entry into her more preferred degrees.

An analogous problem has been documented in the school choice literature. American school applicants have a local 'district school' to which they have priority for entry. 'District School Bias' occurs where an applicant lists her district school above other schools that are in fact more preferred (Chen and Sönmez, 2006). There is also evidence of higher rates of District School Bias in commonly used mechanisms, where, as in the UAC mechanism, the length of ordered lists is constrained (Calsamiglia, Haeringer and Klijn, 2010).

3. Underlying Theory & Experimental Setup

In this section, we provide a brief theoretical characterisation of the general university admissions problem and discuss the theoretical properties of the UAC mechanism. We also characterise the choice environment studied in the experiment and show that it supports a unique optimal ordering.

A finite set A of applicants apply for admission to a degree from a finite set C of degrees, where particular universities administer different degrees. Applicants have strict, i.e., complete, transitive and antisymmetric, preferences over degrees. We represent a generic ordering as $(a) = c_1, c_2, c_3, a, \ldots$, denoting that applicant a prefers degree c_1 first, then degree c_2 , then degree c_3 and then prefers being unmatched to being matched to any other degree besides these. For each degree administered, universities hold strict preferences over individual applicants based on their selection ranks. Let SR_a^c denote the selection rank of candidate a for degree c. Let $P(c)$ denote the strict preference and $R(c)$ the weak preference of degree c. Thus, $a_1 R(c)\, a_2$ if and only if $R_{a_1}^c \geq SR_{a_2}^c$ for any pair of applicants a_1 and a_2 and any degree c. A typical preference ordering may be denoted as $P(c) = a_1, a_2, a_3, c, \ldots$, meaning that the university administering degree c most prefers applicant a_1, then applicant a_2, then applicant

a_3, and then prefers having any remaining places unfilled to being filled by other applicants. Such preferences are induced by the cut-off scores submitted to UAC by each university for each degree. Degrees preferences over sets of students are *responsive* (Roth, 1985).

Unlike standard matching problems, universities do not face admissions caps limiting the number of applicants they can admit to a particular degree. The Australian Government moved to a demand-driven university admissions system in 2009, allowing universities to admit as many applicants as they wish (Australian Government Productivity Commission, 2019). Despite this, UAC refers to there being 'vacancies' after certain offer rounds. The likely explanation for this is that universities decide after an offer round if they will make offers in later offer rounds. They signal a willingness to make further offers, by indicating that there are vacancies.

A (university admissions) *problem* specifies the preferences of each applicant and each degree. A matching is a mapping from A to $C \cup A$ such that each applicant is assigned to at most one degree. A *mechanism* chooses a matching for each problem. A mechanism is *strategy-proof* if truth telling is a dominant strategy for each applicant.

The UAC Mechanism can be viewed as a simple version of the Boston Mechanism (BM). The key difference between the UAC application process and most uses of the Boston Mechanism, is that universities are not bound by admissions caps nor, for all intents and purposes, do physical capacity constraints bind in practice. Therefore, in our setting the Boston Mechanism is equivalent to the Deferred Acceptance Mechanism (Chen, 2014) and, hence, is strategy-proof.

However, the UAC mechanism is not strategy-proof in its current form. This is because applicants can only include a maximum of five degrees in their ordered lists. If an applicant is only considering applying to five or less degrees, then they can still report truthfully. However, if they are considering applying to more than five degrees, then they need to make trade-offs about which degrees to include and exclude (see Haeringer and Klijn, 2009).[18]

[18] The exception to this is if an applicant is considering applying to more than five degrees but has guaranteed entry to one of their five most preferred degrees. In this case, the applicant need not list any preferences below the degree for which she has been granted guaranteed entry.

Our experiment studies a particular example for which the UAC mechanism is strategy-proof. In our example, the set of available degrees is restricted to 6 degrees. That is $C = \{c_1, c_2, c_3, c_4, c_5, c_6\}$. These degrees have associated monetary payoffs, with c_1 having the highest payoff, c_6 having the lowest payoff, and payoffs decreasing monotonically between c_1 and c_6. Assuming applicants prefer more money to less, this induces a common preference ordering, $P(a) = c_1, c_2, c_3, c_4, c_5, c_6, a$. Applicants know the LSRs for each degree in the previous year. However, they are told these should only be used as a guide, as they may change in the current year.[19]

Further, applicants are told that they have guaranteed entry to degree c_5. This means, if they list c_5 first, they know they will be made an offer to c_5 provided that they meet or exceed the LSR associated with it. Similarly, if they list c_5 second, they know they will be made an offer to c_5 if they meet the LSR hurdle and are not made an offer to their first listed degree, and so forth. In any case the unique optimal ordering in this case is to list the degrees in order of *true* preference excluding c_6, specifically $(c_1, c_2, c_3, c_4, c_5)$. This is because under the UAC algorithm the possibility an applicant being made an offer to a particular degree does not depend on where it is listed, except that she will miss out on an offer to a lower listed degree if she accepts an offer to a higher listed degree. Given this particular choice problem, below we identify some ways of ordering degrees that are dominated.

Guaranteed Entry Bias

It is a dominated strategy to list the guaranteed entry degree, c_5, higher than the fifth position. Where it is listed higher than fifth, the preference ordering will be said to exhibit GEB, a term derived from 'District School Bias' in the school choice literature (Chen and Sönmez, 2006). If an applicant lists c_5 higher than fifth, this will not increase her chances of being made an offer to c_5. This is because, if c_5 is listed anywhere, an offer is generated for it unless an offer is generated for a degree listed higher by the applicant. However, listing c_5 higher than fifth, decreases the likelihood of being made an offer to at least one degree from the set

[19] In practice, applicants may also be admitted with an ATAR below a LSR, because they are eligible for adjustment factors. The set of applicants and the description of preferences for universities administering a degree given below are as per the general problem.

$\{c_1, c_2, c_3, c_4\}$, all of which are strictly preferred to c_5. Moreover, listing c_5 higher than fifth and subsequently accepting an offer for c_5, eliminates the chance of being made an offer to any degree listed below c_5 at least one of which must come from the preferred set $\{c_1, c_2, c_3, c_4\}$.

Including c_6

Including the least preferred degree, c_6, is also a dominated strategy. The guaranteed entry degree, c_5, is strictly preferred to c_6. If an applicant lists c_6 above c_5, then they decrease the likelihood of being made an offer to c_5. If an applicant lists c_6 after c_5, then they must have left out at least one degree from the set $\{c_1, c_2, c_3, c_4\}$, all of which are strictly preferred to c_6.

4. Experimental Design

We designed an application task to investigate applicant understanding of the UAC Mechanism. Participants were presented with the choice environment described in Section 3 ensuring that truth telling was their uniquely optimal strategy. Accordingly, the proportion of participants who did not follow this strategy, would provide an indication of the extent of misunderstanding of the UAC Mechanism. The choice data also allowed for examination of *GEB*, as defined earlier. Additionally, we used advice treatment groups and collected demographic information to examine the determinants of sub-optimal ordering.

UAC drew random samples of 2018 NSW Grade 12 students, who applied for 2019 university entry through UAC. We generated a unique survey link to be sent to each potential applicant and provided these to UAC for email distribution.

Across seven waves, UAC emailed 14,500 former applicants, who were randomly selected from the pool of approximately 40,000 applicants. That is, approximately 36% of applicants were emailed. In total, 832 people completed the survey. This corresponds to a response rate of 5.7%.

Participants were first shown a consent question, which required them to acknowledge their understanding of the survey, including the terms of the participant information statement. The survey comprised two parts. First, a matching task, in which participants were asked to apply for hypothetical university degrees. Second, a series of background questions. See Appendix B for the experimental materials.

Participants were presented with a choice environment simulating a main offer round. The choice environment was as described in Section 3.3. That is, participants could apply for up to five out of six degrees with guaranteed entry to their fifth most preferred degree. As in other matching experiments monetary incentives were used to induce a particular preference ordering (see also Chen and Sönmez, 2006; Braun et al, 2014; Rees-Jones and Skowronek, 2018). Specifically, under the assumption that participants preferred more money to less, they should have most preferred the highest paying degree, and then preferred the other degrees in order of decreasing monetary payoffs.

This approach overcomes a key challenge discussed in the empirical matching literature, the inability to observe subjects' preferences. Other techniques used to overcome this challenge have included relying on self-reported preferences (see Rees-Jones, 2018), or examining choice environments where underlying preferences are clear; for example a degree with a scholarship would be preferred to the same degree without a scholarship (see Hassidim, Romm and Shorrer, 2016; Shorrer and Sóvágó, 2018; Artemov, Che and He, 2017).

Participants were informed that the task was similar to applying through UAC. They were then given a set of common information. This included: a common ATAR, a choice set of six degrees, information about those degrees, information about the procedure to be applied, and that they had guaranteed entry to the degree paying the fifth highest amount.

Each participant was informed that they had been awarded an ATAR of 80.00 for the purposes of the task. We chose an ATAR that was at neither extreme of the ATAR distribution. Although the median ATAR in 2018 was 69.95, only 75.4% of NSW students who received an ATAR applied through UAC for university entry (UAC, 2019a); these students, on average, had a higher ATAR, on average, than those who did not apply (UAC, 2019a). Accordingly, an ATAR of 80.00 was chosen to roughly approximate the average of a UAC applicant and hence make the task more familiar for most applicants.

Participants were presented with the first three columns in Table 1, listing six degrees by Lowest Selection Rank (LSR) and the additional payment (beyond the participation payment) they would receive if made an offer.

Consistent with official UAC communications, the 'Lowest Selection Rank' was explained to be the Selection Rank cut-off for admission in the prior year, which could be used as a guide for this year (UAC, 2019b). The 'amount paid if made an offer' was explained to be the amount a participant would be paid - in addition to a $5 participation fee - if she were made an offer to the associated degree.

Participants were then informed about the offer making procedure. They were told that it simulated the UAC procedure. Additionally, participants were told that the further their ATAR below a degree's LSR, the lower their chance of being made an offer to that degree. Finally, they were informed that they had guaranteed entry to the degree with the fifth highest payoff. This was explained to mean that the university offering that degree, had informed them that their selection rank (in this case, their ATAR plus adjustment factors) was above the LSR for Degree 5. Participants were then asked to number a maximum of five boxes, corresponding to the degrees they wished to be considered for. These boxes were presented in a random order to each participant. This ensured that if a participant simply ordered the first 5 degrees from 1 to 5, it is unlikely they would have ordered the degrees in the uniquely optimal way.

Keeping this information constant across participants, helps facilitate comparisons between the ordering decisions of different participants. Participants were randomly assigned to one of four groups. The 'No Advice' group only received the common information. The 'UAC Advice' group received advice about how to list preferences from a UAC publication (UAC, 2018). The 'University Advice' group received advice that a major NSW university used on their website and in publications at the time when the participants were applying for university entry. The 'Combined Advice' group received both pieces of advice. We address a potential experimental demand effect by presenting the advice as being given by UAC or a university. Specifically, participants were told "UAC gives the following advice…" or "The university which runs degree 73207 gives the following advice…".

Through these advice treatments, we could vary what information was displayed to each group of participants. To control for advice that participants received when they applied to UAC, participants were asked to select the forms of advice that they received when applying to UAC.

We assigned to each degree a probability that a participant was eligible to be made an offer to it, in other words, that their selection rank exceeded the Lowest Selection Rank cut-off. These probabilities were designed to simulate the likelihood that a participant with an ATAR of 80.00 would have a selection rank above the listed Lowest Selection Ranks from the previous year. There are two reasons why an applicant with an ATAR below the published Lowest Selection Rank, may in fact exceed the selection rank cut-off for the current year. First, she may be eligible for adjustment factors. Second, the selection rank cut-off may be lower than in the previous year. In the study, we did not inform participants of their adjustment factor eligibility and we informed them that the Lowest Selection Rank was from the previous year and should only be used as a guide.

The probabilities used, but not communicated to participants, are listed in the fourth column of Table 1.

Table 1: Degree Information with Offer Eligibility Probabilities

Degree	**Lowest Selection Rank**	**Amount Paid if made an offer**	***Probability of obtaining an offer (Not Displayed to participants)***
42055	85.00	10.00	*0.10*
19959	82.00	9.00	*0.30*
56769	81.00	8.00	*0.50*
65028	80.50	7.00	*0.75*
73027 (Guaranteed Entry)	79.00	6.00	*1*
82747	78.00	5.00	*1*

We calculated payments by applying the UAC algorithm to degree lists in conjunction with the eligibility probabilities. We coded this procedure into the software program used to run the survey, *Qualtrics*. The program generated a random number between 1 and 1000 for each participant. This was not shown to participants. We then used the display logic function to display a message to the participant with their calculated payment amount based on how she ordered her degrees and if the random number was within certain bounds.[20]

After the matching task, participants were asked a series of questions relating to demographic factors and prior advice (see the Appendix available online). Following this, participants were told how much they were eligible to be paid. They were then asked to provide their cell phone number and register for a PayID to facilitate payment[21]. Payments were made using the CommBank App.

5. Results

Table 2 provides a summary of each outcome variable by advice treatment group. Each column provides the proportions of participants who were part of the listed treatment group, who exhibited each of the outcome variables. We also show the counts for *GEB* and *Including Degree 6* as a percentage of the count for *Sub-optimal Ordering*. As shown in Table 2, the rate of sub-optimal ordering across treatment groups ranged from 70.5% for the UAC Advice group to 80.5% for the University Advice group. The rate of sub-optimal ordering among participants who received no advice was 71.6%. That is, among participants who were reliant on what they remembered about the UAC application process, 71.6% did not tell the truth despite it being optimal to do so. Note that many participants exhibited both the *GEB* and *Including Degree 6* behaviours.

These results suggest that the majority of university applicants may be susceptible to *GEB*. The sub-optimal ordering results indicate a poor general understanding of how the UAC offer

[20] Unfortunately, after the 6th of 7 samples, we discovered that our code did not cover all cases where an offer should be generated. This meant that 146 participants were told they had not received an offer, when in fact they should have. We added to the code before the 7th sample, which greatly reduced, but did not eliminate, the error rate; four more participants were affected. For all affected participants, we manually calculated the correct payments. These participants were sent a text message by UAC explaining the issue and informing them that they would be paid the correct amount. This issue only affected those participants who were not made an offer and should have been. All payments for participants who were made an offer were calculated correctly.
[21] A PayID is a unique identifier, normally a mobile phone number, which is linked to an Australian Bank Account. For more information see https://payid.com.au/.

making process works. It appears that many applicants believe that they risk missing out on their Guaranteed Entry offer unless they place it high on their degree preference list. This may also reflect a fear that if they miss out on the Guaranteed Entry degree, they may not receive any offer at all. As already discussed, some of these results may be exacerbated by inaccurate or misleading university advice implying that an applicant is only eligible for Guaranteed Entry if they list the Guaranteed Entry degree first.

Table 2: Sub-optimal Ordering Outcomes by Advice Treatment Group

	No Advice (%)	**UAC Advice (%)**	**University Advice (%)**	**Combined Advice (%)**
Any Suboptimal Ordering	71.6	70.5	80.5	79.0
GEB	50.5	47.0	63.8	61.4
Including Degree 6	42.8	44.5	47.1	50.5
Number of Observations in Treatment Group	208	200	210	210

The sub-optimal applicant behaviour we have identified would not be problematic if participants who did not list degrees with (prior year) LSRs higher than their ATAR did so because the probability that they would qualify for an offer to these degrees was zero. In fact, in our setting, participants knew that the actual probability of being made an offer to these degrees was non-zeros since, in real life, published prior-year LSRs are subject to change. Also, applicants with an ATAR below the LSR for a particular degree might still qualify for entry if they were eligible for sufficient adjustment factors.

In any case, to rule out the possibility that the sub-optimal behaviour we observe is not, in fact, rational, we examine the proportion of participants who included Degree 6 in their degree list. This is because participants should not have included Degree 6 under any circumstances, provided they understood the UAC offer-generating process.

As shown in Table 2, the rate of *Including Degree 6* varies across treatment groups from 42.8%, for the No Advice group to 50.5% for the Combined Advice group. These proportions are large and offer further support for the inference that there are high rates of misunderstanding among UAC applicants.

Moreover, the UAC Advice group had the lowest rate of *GEB* of 47%. As shown in Table 3, this was 3.5 percentage points lower than the No Advice group, which had a rate of 50.5%. Both the University Advice and Combined Advice groups had much larger rates of *GEB*; 63.8% for the former and 61.4% for the latter.

To gain an idea of the statistical significance of these differences, we run a series of regressions in which we regress indicators for three of the treatment groups on GEB. We also include demographic and prior advice variables as covariates as well as using robust standard errors. For example, to test the statistical significance of differences in *GEB* between the No Advice Groups and the other Treatment Groups, we run the following OLS regression:

$$Guaranteed\ Entry\ Bias_i = \beta_0 + \beta_1 UAC_i + \beta_2 UNI_i + \beta_3 COMBINED + \alpha X' + \nu_i$$

$Guaranteed\ Entry\ Bias_i = 1$, if *i* exhibited $GEB = 0$ otherwise.
$UAC_i = 1$, if *i* was part of UAC Advice group, $= 0$ otherwise.
$UNI_i = 1$, if *i* was part of University Advice group, $= 0$ otherwise.
$INT_i = 1$, if *i* was part of the Combined Advice group, $= 0$ otherwise
X': Vector of demographic and prior advice variables
ν_i: Random error term

The estimates from these regressions are collated in Table 3. For example, on average, a member of the UAC Advice group was 3.05% less likely to exhibit *GEB* than a member of the No Advice group, holding covariates constant.

Table 3: GEB Regressions by Advice Treatment

	No Advice	**UAC Advice**	**University Advice**
UAC Advice	-0.0305079 (0.0504195)		
University Advice	0.1308348*** (0.049345)	0.1613428*** (0.0495788)	
Combined Advice	0.1134185** (0.0494832)	0.1439265*** (0.0493238)	-0.0174163 (0.0487079)

Notes: Standard errors in brackets.
Asterisks indicate significance levels: * = p-value<0.10; ** = p-value<0.05; *** = p-value<0.01
Each cell indicates the coefficient on the Treatment Group in the row, when a regression is run with the Treatment Group in the column as the baseline group.

The rate of *GEB* for the University Advice group is statistically significantly larger than the No Advice and UAC Advice groups at the 1% level. The rate of *GEB* for the Combined Advice group is statistically significantly larger than the No Advice group at the 5% level, and the UAC Advice group at the 1% level. These results indicate that the University Advice both practically and statistically significantly affects how participants listed the Guaranteed Entry degree. Interestingly, a comparable effect persists when it is combined with the UAC Advice. This is despite the UAC Advice producing much lower levels of *GEB* on its own.

These results can be explained by carefully comparing the UAC and University advice. The University advice gives the impression that an applicant will only be made an offer to a guaranteed entry degree if she lists it first. It is true that the only way to guarantee an offer to these degrees is to list them first. Otherwise, an applicant may be made an offer to a higher listed degree instead. However, if an applicant is not made an offer to any degrees listed above the guaranteed entry degree, she will still receive an offer to the guaranteed entry degree. This reality is obscured by the advice and may cause some applicants to list the guaranteed entry degree higher than they otherwise would. If they do this, applicants risk missing out gaining entry to degrees that they would prefer to study.

Crucially, the effect of the (simple but misleading) University advice is found to persist even when combined with the (more complicated but accurate) UAC advice. The UAC advice might be expected to counterbalance the University advice, given it advises applicants to “list their dream degree at number one”. This may have reduced the number of participants who listed the guaranteed entry degree first. However, it does not appear to have reduced the number of participants who listed the guaranteed entry degree above the fifth position. This may be because the remainder of the UAC advice, advises applicants to include one or two ‘safe’ options at the bottom of their preference list. If this caused an applicant to list the guaranteed entry degree in fifth position, then she would not demonstrate *GEB*. However, the language of ‘safe’ options creates ambiguity. Overall, the fact that the UAC advice does not advise on a clear overall strategy may prevent it from counterbalancing the University advice.

In contrast, when we run the same regressions for *Including Degree* 6 we do not find much difference across treatments, see Table 4.

Table 4: *Including Degree 6* by Advice Treatment

	No Advice	**UAC Advice**	**University Advice**
UAC Advice	0.023228 (0.0500546)		
University Advice	0.0342795 (0.0492819)	0.0110515 (0.0506977)	
Combined Advice	0.0882916* (0.0489995)	0.0650636 (0.0496813)	0.0540121 (0.0494967)

Notes: Standard errors in brackets.
Asterisks indicate significance levels: * = p-value<0.10; ** = p-value<0.05; *** = p-value<0.01
Each cell indicates the coefficient on the Treatment Group in the row, when a regression is run with the Treatment Group in the column as the baseline group.

The only statistically significant difference is between the Combined Advice group and the No Advice group, at the 10% significance level. It is difficult to draw any strong conclusions from this given the low level of significance. However, it does make intuitive sense that the Combined Advice group produces the highest rate of *Including Degree 6*. Based on the UAC Advice, participants may have included one or two safe options at the bottom of their list. The Guaranteed Entry degree would likely be perceived as the best safe option, followed by degree 6. However, based on the University Advice, participants may have been prompted to list the guaranteed entry degree first. If they did so and also followed the UAC advice of including a safe option at the bottom of their list, then they would have listed degree 6. By contrast, participants following the UAC advice alone may have only included the guaranteed entry degree as a safe option depending on whether they decided to include one or two safe options.

We also examine the contribution to demographic factors and prior advice, controlling for treatment group assignment, on the outcome variables. We report the estimates from these regressions in the Appendix.

All else equal, we estimate that students from non-selective public schools were 6.9% and 8.2% more likely to exhibit GEB than students from private and selective schools, respectively. These estimates are significant at the 10% level. We also estimate that students from non-selective public schools were 4.8% and 17.3% more likely to exhibit *Sub-optimal Ordering* than students from private and selective schools, respectively. The estimated difference between non-selective public and selective students is significant at the 1% level. We observe no significant variation in *Including Degree 6* across schools.

These results suggest that students from non-selective government schools understand the offer making process the least. This may be due to private and selective schools investing in sources of advice, such as careers advisors. Or, as earlier studies suggest, low ability students may be most affected by mechanism misunderstanding (see Basteck and Mantovani, 2018). Regardless, these findings suggest that students from relatively disadvantaged schools may be more exposed to the consequences of sub-optimal ordering.

Finally, we also estimate that women are 7.2% more likely to include degree 6, significant at the 5% level. All other gender differences are not statistically significant.

6. Discussion

Our results suggest that a large proportion of applicants seeking admission to NSW universities do not have a clear understanding of how UAC makes offers. This lack of understanding manifests as applicants ordering degrees in a way that reduces their chances of being made an offer to their most preferred degree. Although advice might be thought to help solve this problem, we show that if inaccurate, it can exacerbate it. Furthermore, the results suggest manipulation may be more characteristic of applicants from non-selective compared to academically selective schools and, perhaps, may even affect women more than men. These results are concerning; there is no reason to want to hinder applicants as they apply for entry. In fact, increasing transparency in university admissions is an Australian Government objective (HESP, 2016).

Removing the constraint on the length of applicant degree preference lists would make the UAC mechanism strategy-proof and allow for far simpler advice to be given. Applicants would simply need to be told that it is optimal for them to tell the truth. While existing work shows that it is unlikely that this would prevent manipulation entirely, it should lower sub-optimal behaviour, both generally and among particular demographic groups. Of degree, implementing such a change might not be straightforward in practice given the number of applicants and degrees involved in the UAC mechanism and the fact that such a fundamental change in the admissions process would need, itself, to be clearly communicated and justified to all stakeholders.

Nevertheless, if applicants are advised to tell the truth, then this should also help with responding to inaccurate advice. In this study we focused on inaccurate advice relating to Guaranteed Entry. However, there may be other information sources causing confusion for applicants. Clear advice likely stands the best chance of responding to inaccurate advice. Although the UAC advice produced the lowest rate of *GEB* when given alone, when combined with the University advice, it produced a similar rate of *GEB* to that observed when only the University advice was given. We infer that the UAC advice fails to counterbalance the University advice, because it does not advise a clear strategy. Removing the constraint on the length of applicant degree preference lists would allow for unconditional truth-telling to be advised instead.

Removing this constraint should also help reduce rates of *GEB* that may exist even in the presence of accurate advice. Calsamiglia, Haeringer and Klijn (2010) find that priority entry biases are more prominent in constrained choice environments. This is because, in the presence of a constraint, applicants are required to make trade-offs between degrees that they want to apply for. As such, clarifying the role of Guaranteed Entry in a system like that managed by UAC is particularly important. For example, in the UAC mechanism, universities could be required to publish an upper bound on the LSR, which applies irrespective of where applicants list a degree.

This study has also highlighted the importance of providing accurate advice in high-stakes settings such as that managed by UAC, especially when that advice is disseminated by market makers – the universities in our case – who are implicitly trusted by applicants. Perhaps coincidentally, one university which used the (inaccurate) advice quoted earlier changed its published advice after our study commenced. This new advice now reads:

"To be offered a place in a guaranteed-ATAR course[22], list the course as your *highest eligible preference* when you apply" (our emphasis).

We contend that the new advice only replaces its inaccurate predecessor with a statement that may still be misunderstood by applicants. Although guaranteed entry schemes are meant to provide safety nets for applicants, the new advice may encourage applicants to prematurely exercise a safety option by listing a guaranteed entry degree above more preferred degrees. Moreover, applicants are generally not in a position to ascertain what their highest eligible preference is; they may prefer another degree to a guaranteed entry degree but remain uncertain about whether their selection rank exceeds the relevant LSR. As such, we believe the *GEB* is likely to persist.

7. Conclusion

We have introduced the Australian university admissions system in New South Wales which is based on a central clearinghouse with innovative features. Guaranteed entry schemes are novel schemes that resemble and aim to serve similar purposes as Early Admission programs in the decentralized college admission system in the US. However, we caution that conflicting advice can significantly undermine the intended benefits of such schemes.

To our knowledge, this study is the first to experimentally assess, in the field, applicant understanding, in a matching process that is not strategy-proof, and where applicants are not advised on clear strategies to follow. We construct a choice environment where truth telling is the unique optimal strategy. The results are indicative of widespread misunderstanding of the

[22] In Australia the word 'course' is synonymous to and often used instead of 'degree'.

UAC mechanism by applicants. Ours is also the first to experimentally assess the effects of advice given by a market operator and market actor, in a field setting. We find that inaccurate advice given by a market actor significantly increases rates of manipulation. Further, this effect persists when the inaccurate advice is given alongside the accurate yet somewhat unclear advice of the market operator. This suggests that market operators need to pay close attention to the advice being given by market actors.

Additionally, this study is the first to experimentally assess, in the field, rates of district school bias, or what we term GEB, in this setting. We find that the majority of applicants list a degree that they are guaranteed to be made an offer to, higher than is optimal. This form of bias is more common than another form of dominated degree ordering; including a degree with a lower payoff and selection rank, than the guaranteed entry degree. It is also greatly affected by advice directed towards the ordering of guaranteed entry degrees.

We also find evidence of rates of suboptimal ordering and GEB being associated with school types. There is also some weak evidence of outcomes differing by gender. This suggests that misunderstanding in this mechanism, and perhaps in others, may be correlated with demographic factors. This is a concern for mechanism operators and policymakers, as matching processes should not disadvantage particular demographic groups.

These findings may provide a basis to make changes to the current application process and the advice given to applicants. If the constraint on applicant ordered list sizes is removed, the UAC mechanism would be strategy-proof. This would allow for the provision of clear and concise advice by UAC which is likely to improve applicant understanding and decision making.

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Appendix: Regressions on Demographic Variables

Demographic Variables	**Sub-optimal Ordering**	**Guaranteed Entry Bias**	**Including Course 6**
School Type (Baseline: Public non-selective)			
Selective School	-0.1730237***	-0.0823239*	-0.0349388
	(0.0436428)	(0.0488622)	(0.0482155)
Private School	-0.0481998	-0.0694261*	-0.0264575
	(0.0328858)	(0.0397025)	(0.0404051)
Sibling Order (Baseline: First Sibling)			
Second Sibling	0.030191	-0.0471175	0.0588088
	(0.0368237)	(0.044335)	(0.0446339)
Third Sibling	-0.0348521	-0.0019748	-0.01626891
	(0.055487)	(0.0626968)	(0.0611067)
Fourth Sibling	0.1428417**	0.2053134**	0.2003278**
	(0.0615024)	(0.0859653)	(0.0943831)
Fifth Sibling	0.0607248	0.0588969	0.1480918
	(0.1138756)	(0.1361704)	(0.1445582)
Gender[23] (Baseline: Male)			
Female	0.0505651	0.0383035	0.0717123 **
	(0.0320839)	(0.0366713)	(0.0363655)
Other	0.2417812***	0.4100679***	0.5117445***
	(0.0530707)	(0.0632907)	(0.0606678)
Prefer Not to Say	0.2130404***	0.4829695***	0.5785651***
	(0.0456316)	(0.0550044)	(0.0563346)
Prior Advice			
UAC Website	-0.0499197	-0.0072648	-0.0528443

[23] Other and Prefer Not to Say only had 2 observations each

	(0.0373949)	(0.0451305)	(0.0459851)
UAC Publications	-0.0254402	-0.020941	0.0630596
	(0.0372016)	(0.0421276)	(0.0418656)
University Websites	-0.0035124	0.0046983	0.0620312
	(0.0381329)	(0.0425837)	(0.0426888)
University Open Day	0.0633277*	0.0149999	0.019771
	(.0353479)	(0.0401358)	(0.0404339)
Careers Advisor	-0.0293928	-0.0119612	0.0492471
	(0.0343736)	(0.0401931)	(0.0417442)
Teachers	0.0042787	0.0119029	-0.0177682
	(0.0329857)	(0.0385143)	(0.0392569)
Parents	-0.0073034	-0.0159831	-0.0436285
	(0.0391408)	(0.0464301)	(0.0459264)
Siblings	0.0023231	0.0391805	-0.0229908
	(0.0490336)	(0.0572318)	(0.0571947)
Extended Family	0.0098752	-0.0781001	-0.0966
	(0.0688999)	(0.0778949)	(0.0775775)
Friends	-0.0037184	-0.0258487	0.032548
	(0.0382782)	(0.0432348)	(0.0430943)
Other	0.0036133	0.0097754	-0.1515051
	(0.1042272)	(0.1280365)	(0.1305849)
Location (Baseline: Outside of Sydney)			
Sydney	-0.0453206	-0.039781	-0.0516568
	(0.0337144)	(0.0411798)	(0.0413119)

Note: Standard errors in brackets.
Asterisks indicate significance levels: * = p-value<0.10; ** = p-value<0.05; *** = p-value<0.01