

## UMS performance and the eventual HE destination of Cambridge applicants

The emphasis placed on attainment at AS-level in the Cambridge admissions process makes it very probable that those applicants who are successful in obtaining an offer of a place at the University have a stronger academic record than those who are unsuccessful. While it is difficult to capture in statistics the full assessment made of an applicant's academic record, a proxy through which to operationalise relative attainment is through the use of UMS.

This short paper therefore tests the hypotheses that:

- The UMS attainment of applicants made an offer of a place at Cambridge is significantly higher than those not made the offer of a place, and,
- That this relationship is consistent across all Tripos subjects for which students are admitted, and,
- That differentiation in UMS attainment is consistent across the sector, in that the Cambridge applicants with the highest attainment tend to attend the more selective universities.

### Methodology

This paper uses a combination of t-tests and one-way ANOVA to investigate statistically significant differences in average UMS performance between groups.<sup>1</sup> Where values of p are less than 0.05, we can be 95% confident that the differences observed between the group means could not have occurred by chance, and are indeed reflective of a difference in the population in observation.

In all subjects, regardless of their subject group at the University, the mean value of the best three AS-level UMS subjects is used. All those students who have UMS information are included in the analysis, regardless of whether they received a conditional or unconditional offer.

Higher education destinations are based on data received from UCAS at the end of the cycle about the other institution choices, offers and replies made by each Cambridge applicant. Those who have a firm decision, after confirmation, for a given university are treated as having been accepted by that university in this study. This is, of course, not entirely reliable, inasmuch as we do not possess records of matriculation at other universities. However, given that decisions to accept an applicant at the point of confirmation are largely based on academic attainment, we can be confident that these results offer a complete picture of those candidates with sufficient grades to enter the universities which accept them, even if, for other reasons, a small minority may not actually be admitted to them.

A total of 41,054 individuals are included in the dataset, which comprises the five completed admissions cycles from 2009 to 2013 inclusive. This means that even in the smallest Tripos subjects, there are sufficient observations to conduct statistical analyses on differences between groups.

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<sup>1</sup> Note that the t-test is a parametric test, and relies on the assumptions that the means are normally distributed and have homogeneity of variance. As the latter assumption is regularly violated, Mann-Whitney U tests were also conducted for each subject, and the patterns of significance detected were not materially different from the t-test statistics discussed above. ANOVA is relatively robust, but where appropriate, alternative calculations of F (Welch) and appropriate post-hoc procedures (Hochberg's GT2 and Games-Howell) are reported.

### **UMS attainment of offer recipients and unsuccessful applicants**

Taken as a whole, successful and unsuccessful applicants to the University of Cambridge are a large and very well qualified group. Most applicants have attainment at the higher end of the possible distribution for UMS, and certainly in the most competitive courses, there can be very highly qualified applicants who are ultimately unsuccessful in their application.

It nevertheless should be possible to detect an overall difference in the means of the UMS performance of successful and unsuccessful applicants, partly because of the emphasis placed on prior attainment and indeed on the UMS average in parts of the admissions process, and partly because the selection of the most highly qualified applicants is in Cambridge's best interest. Even if, on the scale of the individual, there will certainly and justifiably be cases where applicant a, with a lower UMS average is successful, while applicant b, with the higher average is not, at the University-wide level, we would expect the applicants with the highest scores to be accepted.

Whether this difference is statistically significant tells us something about the distribution of applications – a very small difference in real percentage terms might be statistically significant in a population of this size – and also about the overall admissions process: that is, whether Cambridge selects those with higher UMS at a statistically significant level.

Table 1 below shows the results of an independent t-test on the UMS marks of successful and unsuccessful applicants to the university between 2009 and 2013 inclusive. Note that Levene's test for homogeneity of variance is significant. This means that we must use a stricter statistical threshold for significance, which does not require this assumption to be satisfied, in order to avoid Type 1 errors in our results.<sup>2</sup>

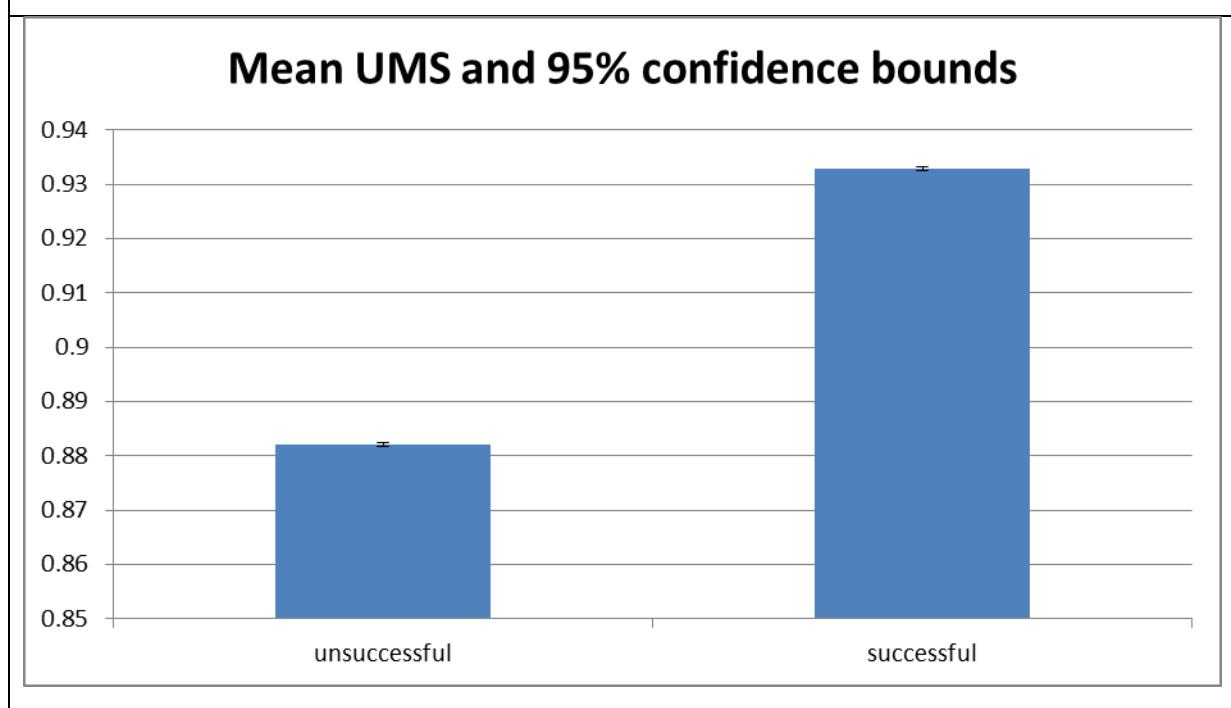
*Table 1. T-test of UMS for whole population of applicants, by success, 2009-13.*

		Independent Samples Test		t-test for Equality of Means								
		Levene's Test for Equality of Variances		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
											Lower	
											Upper	
Best3 UMS Av	Equal variances assumed	778.6	70	97.65	0.000	410.52.0	40	0.00	-0.051	0.001	-0.052	-0.050
	Equal variances not assumed	33	91	10.5.7	0.000	351.76.2	32	0.00	-0.051	0.000	-0.052	-0.050

<sup>2</sup> We could also use a non-parametric test, like the Mann-Whitney-U test. In this situation, the value of Mann-Whitney-U is also significant at the p<0.001 level. (Total N: 41,054; Mann-Whitney U: 297,964,800; Asymptotic Sig.: 0.000).

We can see that the t statistic, when equal variances are not assumed, is statistically significant at the p<0.01 level, which means that we can be 99% confident that we observing a meaningful and not a random difference between the mean UMS performance of the two groups. A clearer illustration of this statistic is provided in Figure 1 below, which graphs the mean UMS score, and the 95% confidence interval for values of the mean, for the successful and unsuccessful applicants. The difference in the mean UMS of successful and unsuccessful applicants is clear and substantial.

*Figure 1. Observed difference in mean UMS, for all subjects*



#### UMS attainment by Tripos subject

At the finer resolution of the Tripos subject, we might anticipate different degrees of divergence in the means, but that there would remain a statistically significant difference in mean UMS between successful and unsuccessful applicants. Table 2 below is a summary of the t-tests for each Tripos subject, and we can see that the expected pattern of significance is upheld, at the 99% confidence level for all subjects. Note that where Levene's test is significant, the values of t given are those which do not assume equality of variance.

*Table 2. Model summary of t-tests for UMS by Tripos subject*

	Unsuccessful Mean	Successful Mean	Unsucc St.Dev.	Succ St.Dev.	Levene p<0.05	T statisti c	Sig 0.01
ASNAC	0.832	0.892	0.047	0.049	n	-7.073	y
Architecture	0.880	0.924	0.052	0.039	y	-12.694	y
AMES	0.853	0.914	0.055	0.044	y	-11.095	y
ChemEng	0.889	0.944	0.051	0.035	y	-17.602	y
Classics	0.872	0.911	0.047	0.045	n	-9.943	y
CompSci	0.860	0.921	0.055	0.045	y	-17.061	y
Economics	0.899	0.948	0.047	0.033	y	-30.184	y
Education	0.847	0.883	0.055	0.049	n	-4.730	y
Engineering	0.876	0.936	0.053	0.039	y	-39.274	y
English	0.881	0.926	0.054	0.044	y	-22.956	y
Geography	0.884	0.931	0.045	0.040	y	-18.675	y
History	0.880	0.932	0.052	0.038	y	-27.301	y
History of Art	0.881	0.924	0.052	0.042	y	-7.499	y
HSPS	0.869	0.920	0.052	0.045	y	-9.689	y
Land Economy	0.873	0.916	0.051	0.042	n	-9.220	y
Law	0.872	0.929	0.060	0.037	y	-26.507	y
Linguistics	0.858	0.901	0.053	0.048	n	-5.926	y
Maths	0.868	0.933	0.060	0.043	y	-39.134	y
Medicine	0.908	0.958	0.049	0.028	y	-39.76	y
MML	0.868	0.916	0.052	0.044	y	-20.287	y
Music	0.854	0.905	0.051	0.049	n	-11.079	y
NatSci	0.886	0.947	0.051	0.033	y	-60.187	y
Philosophy	0.876	0.926	0.052	0.038	y	-14.461	y
PBS	0.864	0.922	0.042	0.036	y	-13.437	y
Theology	0.868	0.917	0.048	0.045	n	-10.135	y
Vet Med	0.873	0.941	0.054	0.031	y	-24.101	y

The pattern which emerges above could not be clearer. For all subjects, and at the highest confidence level, we can see that there is a statistically significant difference in the mean UMS performance of successful and unsuccessful applicants.

#### **HE destinations of unsuccessful applicants**

Although the results have this analysis have very clearly demonstrated that those applicants who are successful in their application to Cambridge have a higher UMS average than those who do not, in every subject, there remains a possibility that other universities, especially those which also select

extensively on academic performance to date, could be performing equally well in capturing those applicants who are unsuccessful at Cambridge, but who may achieve higher UMS than the group of unsuccessful applicants as a whole.

In order to differentiate more fully between the group of unsuccessful applicants, we can explore their eventual higher education destination, captured through a firm response to UCAS and unconditional offer of a place at confirmation. We might speculate that the group of unsuccessful applicants who go on to study at highly selective universities will have a more similar UMS performance to those accepted at Cambridge, while those who go on to less highly selective universities might differ more strongly on this metric.

This is important because the presence of a statistically significant difference between attainment of students accepted to Cambridge and its applicants who ultimately went on to study at its competitors would provide a more robust validation of the impact of using UMS as an admissions metric than the difference between successful and unsuccessful applicants en masse. It would therefore suggest that a strong focus on academic attainment at Cambridge is demonstrably present in its admissions processes.

It should be noted, however, that this analysis can only capture those students who choose to apply to Cambridge. We have no sense of the relative attainment of those students who apply elsewhere, and do not include Cambridge as one of their UCAS choices. Our conclusions can only be extended as far as the population of Cambridge applicants, and cannot tell us about the mean UMS attainment of students who attend other higher education institutions as a whole.

Returning, then, to a dataset which comprises the whole population of applicants with UMS information between 2009 and 2013, we can conduct one-way Analysis of Variance (ANOVA), to determine whether there is a statistically significant difference in group means, for groups based on the mission group of the higher education institution to which applicants were ultimately accepted. The mission groups included in this analysis are: Russell Group, 1994 Group<sup>3</sup>, University Alliance, Million+ and Guild HE.<sup>4</sup> Cambridge is coded separately from the Russell Group, to allow comparisons with it to be made. Note that no hierarchy of institutions is made explicit by this classification, but arguably it is the categories of Russell Group and 1994 Group which contain those higher education institutions we might regard as highly selective.

The total number of applicants with UMS to Cambridge who ultimately received a confirmed place at a university that could be classified above is 40,286 individuals, which is 98% of our original dataset. The remaining two per cent are excluded from this analysis.

Table 3 below shows the results of the one-way ANOVA on mean UMS of applicants accepted at Cambridge, and at other higher education mission groups. Note that Levene's test is significant, which means that we must use a more robust measure of the F statistic (Welch's F) in order to determine whether there is a statistically significant difference between the means of the groups.

<sup>3</sup> Although this mission group is now defunct, it is still included here as a proxy for the selective institutions who formerly belonged to it. Any institution which left the 1994 group for the Russell Group is, however, included as a Russell Group member.

<sup>4</sup> Unaligned universities are excluded, as are those HEIs which could not be classified into the categories above.

*Table 3. One-way ANOVA on mean UMS and HE mission group*

<b>ANOVA</b>					
Best 3 UMS average					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	25.387	5	5.077	2120.699	0
Within Groups	96.438	40280	0.002		
Total	121.825	40285			
Robust Tests of Equality of Means					
	Statistica	df1	df2	Sig.	
Welch	2383.745	5	72.196	0	

The value of Welch's F given above is 2383.7, which is significant at the p<0.01 level. This means that the overall ANOVA model has found statistically significant differences in the mean UMS performance of Cambridge applicants ultimately accepted by the mission groups. However, in order to find out more precisely where those differences lie, we require post-hoc tests. In this instance, since we cannot assume homogeneity of variance, we must use the Games-Howell post-hoc procedure to make comparisons between Cambridge and the mission groups.

Table 4 below shows only the comparisons between Cambridge and all other mission groups, and the Russell Group and other categories. Mean differences equate to percentage UMS, and all differences between the groups are significant at the p<0.05 level.

*Table 4. Games-Howell post-hoc comparisons in mean UMS*

		Mean		
		Diff	p	p<0.05
Cambridge	Russell Group	0.049	0.000	y
	Old 1994	0.068	0.000	y
	University			
	Alliance	0.120	0.000	y
	Million+	0.160	0.000	y
	Guild HE	0.150	0.000	y
Russell Group	Cambridge	-0.049	0.000	y
	Old 1994	0.018	0.000	y
	University			
	Alliance	0.072	0.020	y
	Million+	0.110	0.030	y
	Guild HE	0.102	0.020	y

From the Games Howell post-hoc procedures, we can conclude that successful applicants in Cambridge have a higher mean UMS than applicants who were unsuccessful at Cambridge but successful at any other group of institutions. The closest to Cambridge in terms of mean UMS are those applicants who were unsuccessful here but successful elsewhere in the Russell Group, while

the lowest mean UMS relative to successful Cambridge applicants is observed at students who were ultimately accepted at a Million+ institution.

The Russell Group excluding Cambridge is also statistically significant in terms of the difference observed between its successful applicants and those successful elsewhere, and it is superior to all other mission groups, apart from Cambridge.

### **Conclusion**

There is, perhaps, little to surprise in this paper. In the university as a whole, and for each of its individual Triposes, those who are successful in their applications show a statistically significant superiority in terms of mean UMS than those who are unsuccessful. This difference remains, even when we examine the pool of unsuccessful applicants in more detail, looking at those who go on to other highly selective universities. There is, it seems, a clear basis for the statement that those applicants who are successful in their applications are those with the strongest academic record.

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