

# MMG Interim Evaluation 4: Statistical Analysis

Colin R Reeves

Email: C.Reeves@coventry.ac.uk

## Abstract

This report contains an analysis of the current situation regarding the factors affecting the number of graduates in Mathematical Sciences from UK universities. The main features evident are (a) an initial precipitous fall in the size of the pool of potential candidates after the introduction of Curriculum 2000, followed by a slow but steady increase in numbers; (b) a general increase in undergraduate numbers, especially in part-time students; (c) a general increase in the number of graduates in Mathematical Sciences; (d) a clear imbalance between the number of girls and boys studying Mathematics at post-16 level.

## 1 Introduction

As a background investigation for the More Maths Grads project, it is important to establish the baseline from which the effects of any interventions might be distinguished. An obvious starting point is to examine data from the recent past in order to establish the current position, and to determine whether there are any existing trends that might be expected to continue.

There are three initial quantities of interest:

- the ‘pool’ of potential candidates—those obtaining an A level in Mathematics at a sufficient grade to enter an HE course in Mathematical Sciences (MS);
- the number of undergraduates studying MS degrees;
- the number graduating with a degree in MS.

## 2 Data Analysis

### 2.1 GCSE data

GCSE data were obtained from the Jount Council on Qualifications (JCQ) website [1], which provides annual tables of GCSE, AS and A grades in all subjects in England, Wales and Northern Ireland. The numbers studying Mathematics at GCSE has varied between 690000 and 760000 over the years 2001 to 2008. Relative to all GCSE subjects taken, the proportion taking Mathematics has risen, as displayed in Figure 1. Note that this is not the same as the actual percentage of *candidates* sitting GCSE Mathematics, which as Mathematics is a core subject must be much higher, but it provides an indication of the ‘weight’ of Mathematics in secondary school education.

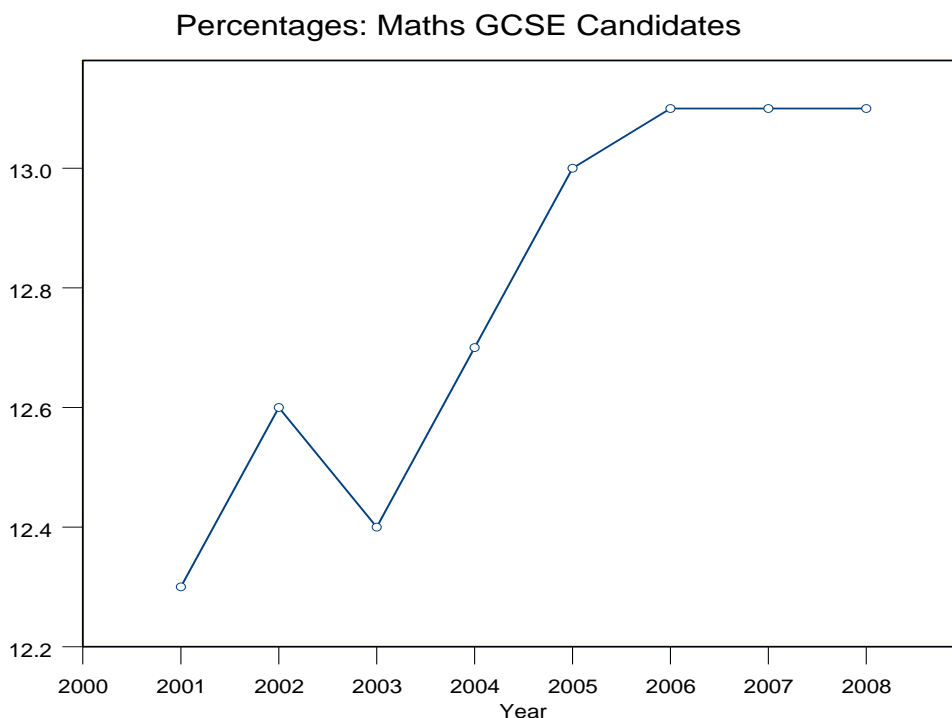


Figure 1: Mathematics as a percentage of all GCSE subjects.

From the perspective of this project, the proportion obtaining an A or A\* grade will have an impact on the number studying A level, and thus on the pool of potential Mathematics undergraduates. This has increased uniformly since 2003, as is shown in Figure 2. It is also interesting to note that girls have improved disproportionately; in 2001 the proportion of boys obtaining A/A\* was 11.3% compared with 11% for girls, but in 2008 the order is reversed at 14.1% to 14.8%.

Thus the potential number of candidates for AS level study of Mathematics has risen. The graph at Figure 3 shows that the number of AS candidates is well predicted by the number of GCSE passes at grade A and A\* the previous year. The proportion of AS students relative to GCSE A/A\* passes has fluctuated from year to year, but seems to be anchored at about 78% with little discernible trend. It seems reasonable that the main ‘engine’ for growth in AS Mathematics numbers is the increasing number of A/A\* passes at GCSE.

## 2.2 A and AS level data

The base data were again compiled from the JCQ’s annual tables. From these, collated data were obtained for the years 2001-2007 for Mathematics (A and AS), and for 2003-2007 in the case of Further Mathematics. Aggregate data were investigated, although separate data were available for the 3 countries concerned, and in every case results were also listed by sex.

In each year of the JCQ tables, the previous year’s figures are stated for comparison; this provides a means of checking accuracy. Some discrepancies were found: the AS level figures from the 2002 tables were noticeably different from the values tabulated in 2003 as ‘previous year’. No explanation was given for what was in some cases a substantial difference. It was decided to use the later values, on the assumption that an error had been discovered and corrected. The ‘corrected’ figures also fitted the overall trend better.

The year 2000 marked the introduction of a new scheme for A levels (Curriculum 2000), so data from earlier than 2001 (the first year in which exams were taken under the new format) may not provide a meaningful comparison. However, in most instances, the 2000

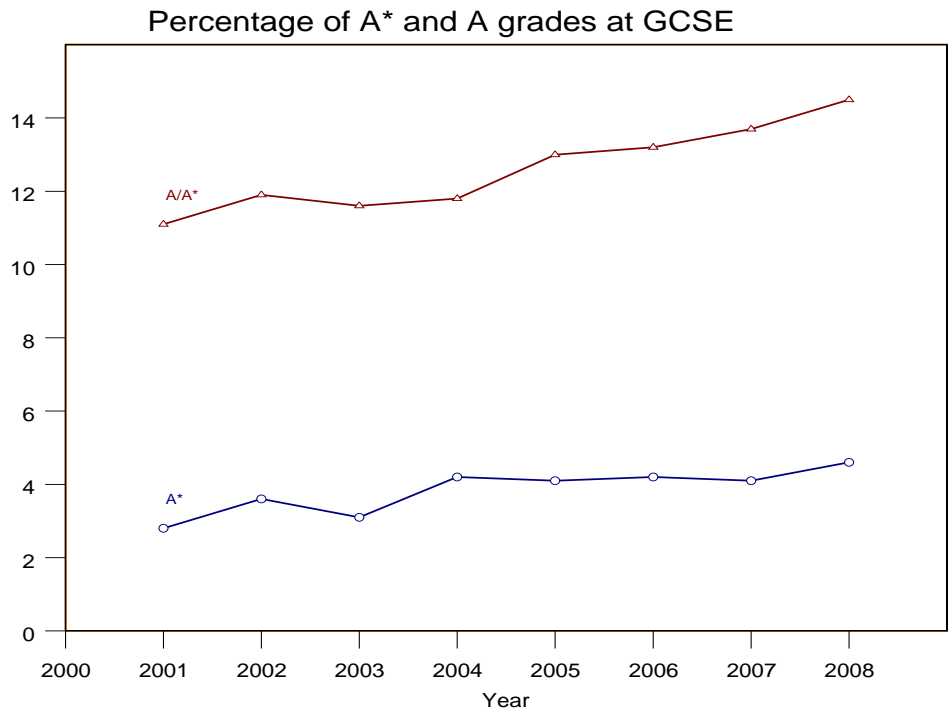


Figure 2: The percentage of candidates obtaining at least an A grade at GCSE.

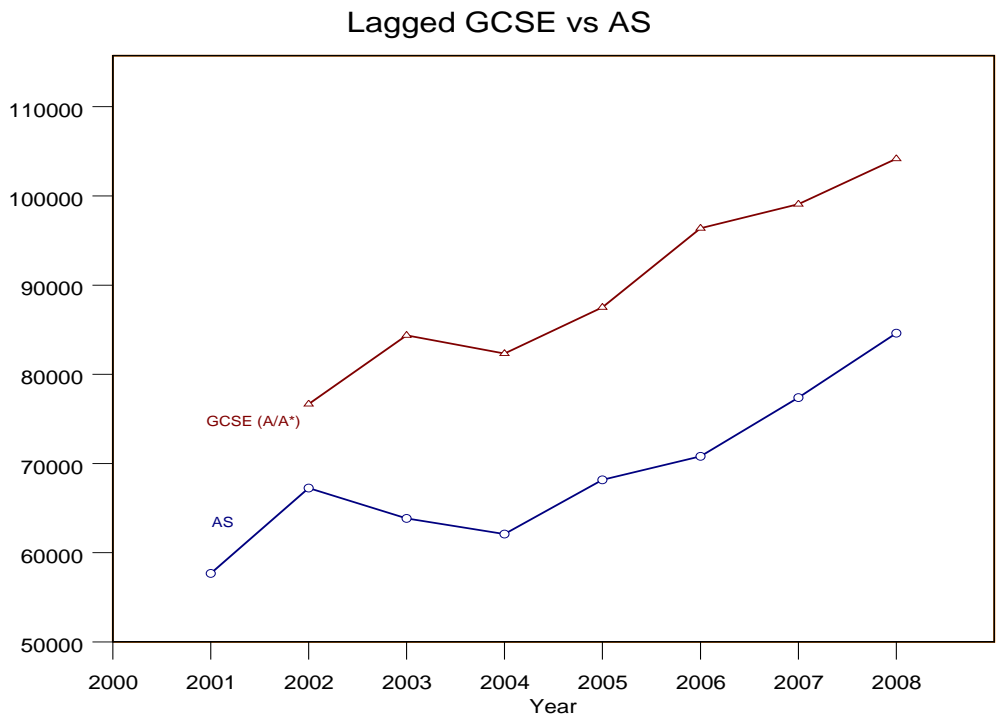


Figure 3: The effect on AS level candidacy of GCSE grade obtained the previous year.

### Mathematics A level Candidates

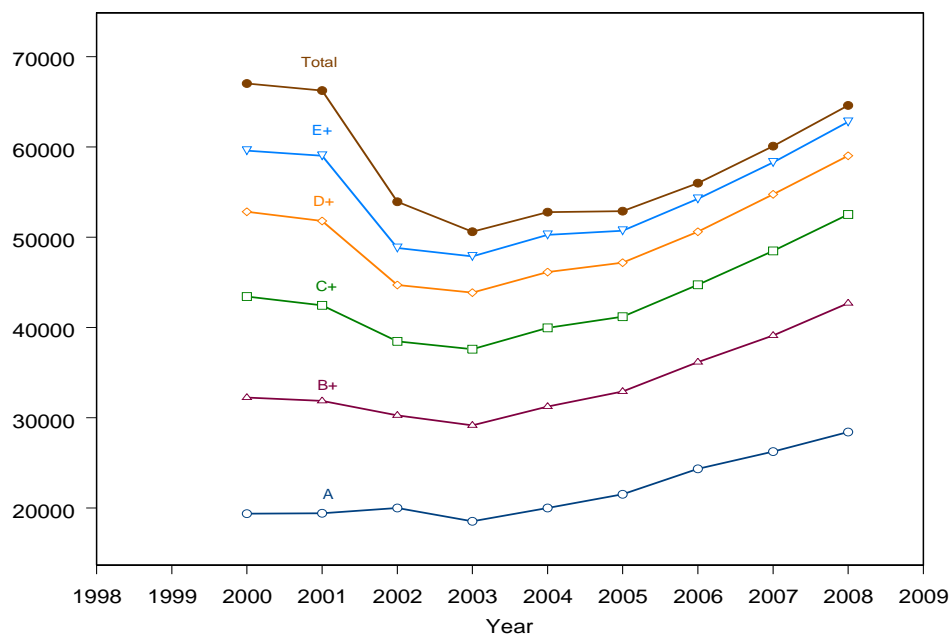


Figure 4: The number of A level candidates in Mathematics. The lines relate to the numbers with a pass at different levels: e.g., C+ means students who obtained at least a C grade.

figures were given in the 2001 tables.

The values for AS levels in 2001 also pose a problem, in that there were still some ‘legacy’ candidates from the old scheme (‘Advanced Supplementary’), whose pass rates were significantly lower than those on the new ‘Advanced Subsidiary’ examination. Data for 2001 can be obtained by conflating the C2000 and legacy results, but doubts as to their validity remain.

Given the nature of the subject, students with A level passes in Mathematics are bound to form the vast majority of entrants for degrees in MS<sup>1</sup>. As Figure 4 shows, the size of this ‘pool’ shrunk dramatically after the introduction of Curriculum 2000, but since 2003 there has been a steady upwards trend—in particular, for those that could be considered most likely to pursue such a degree: those with at least a C grade.

While numbers have started to increase, in percentages terms the situation is not so good. Figure 5 shows the percentages of A level Mathematics relative to all subjects at each year’s sitting. Again, this is not the same as the percentage of all A level students who take Mathematics, but given that there is a choice (unlike GCSE) and that the number of subjects taken is smaller than at GCSE, it is likely to be a reasonable surrogate.

The graph shows a precipitous fall after the introduction of C2000, and not until 2007 did any marked change occur. It is also worthy of mention that the proportion of boys taking Mathematics A level is roughly double that for girls. There is a slight trend for the proportion of girls to increase: in 2008 the female proportion of the total number sitting Mathematics A level rose above 30% for the first time.

One matter of interest is the effect of AS level results on subsequent A levels. In Figure 6 A level results at time  $t$  are plotted against AS level results at time  $(t - 1)$ . It appears that, apart from the anomalous years 2001 and 2002, the number of grades A-C at AS level is a fairly good predictor of the number of A-C grades at A level the following year. (The

<sup>1</sup>UCAS data records HND and ‘other’ qualifications, but the numbers are tiny.

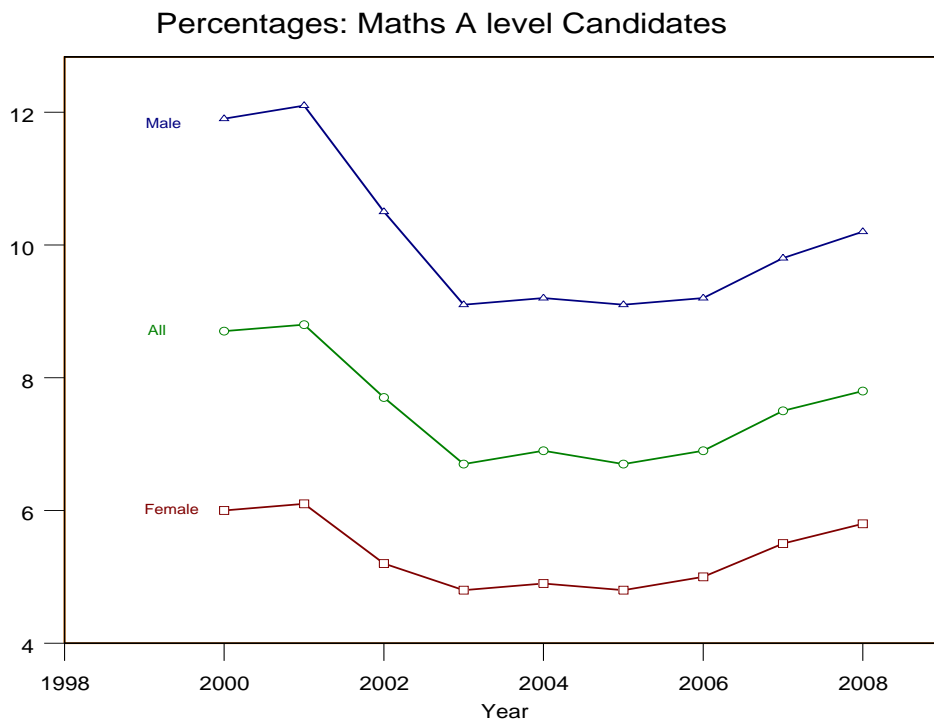


Figure 5: Mathematics as a percentage of all A level subjects.

effect is possibly even more obvious if restricted to A grade passes only.) It can also be seen from the plot of ‘All grades’ that many of the students with poor AS grades do not follow through to A level the following year.

There is, however, considerable anecdotal evidence suggesting that the picture will be clouded by the ‘cashing-in’ phenomenon. That is, students whose AS grades were below expectation at the first attempt will not accept their grades, but repeat the examination during Year 13 in an attempt to improve. Of course, we have no way of knowing how widespread this pattern of behaviour is.

There is also a striking change in the *relative* numbers of boys and girls moving on from AS to A level Mathematics. The Male/Female ratio changes from approximately 60:40 at AS level to 70:30 at A level. This is at odds with the relative performance of boys and girls: a higher percentage of girls obtain the higher grades—a fairly consistent 3% extra at grade A, and 5% at A and B combined. Presumably more girls than boys with lower AS grades give up on doing the full A level.

## 2.3 Further Maths

The numbers studying Further Mathematics has increased substantially. Figure 7 shows a vigorous growth since 2003. In fact, according to a recent press article [2], Further Maths is currently the fastest growing subject at A level. One factor in this success has apparently been the availability of specialist help via the Further Maths Network [3]. Although not plotted here, percentages have also increased significantly. (Relative to all A level subjects, however, it is still less than 1%.)

Presumably also, of those studying Further Maths, a large proportion will proceed to study Maths at undergraduate level. Knowledge of conversion rates would be useful, but requires further investigation of data sources.

### A levels vs lagged AS levels

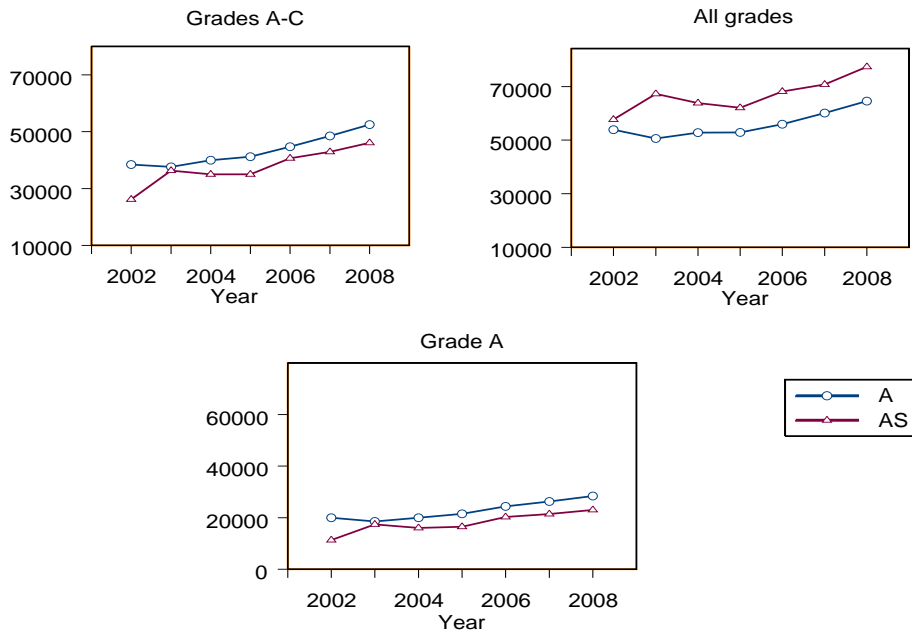


Figure 6: The effect on A levels of AS level results a year earlier.

### Further Mathematics A level Candidates

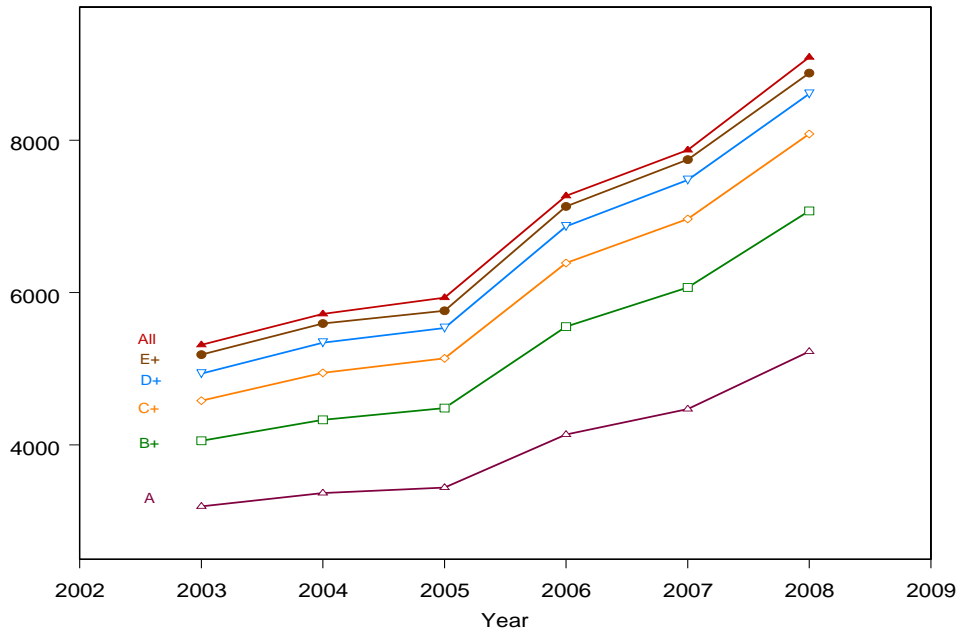


Figure 7: The number of Further Maths candidates since 2003. The lines relate to the numbers with a pass at different levels: e.g., C+ means students who obtained at least a C grade.

## UCAS Degree Acceptances: MSOR

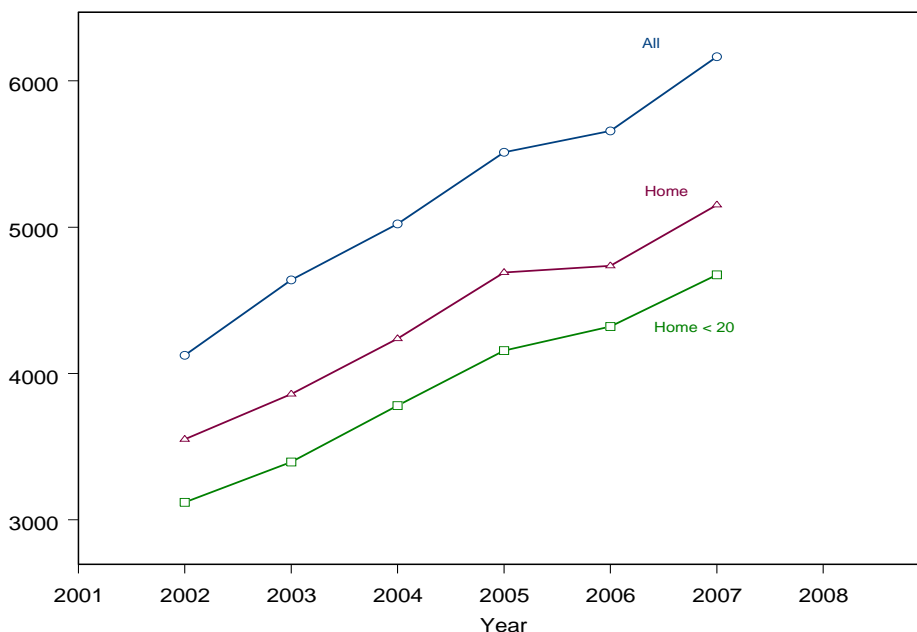


Figure 8: The approximate number of undergraduates entering Mathematical Sciences. ‘Home < 20’ means students aged 19 and under, the category that comprises most entrants.

### 2.4 University entries

The Universities and Colleges Admissions Service (UCAS) publishes data from various perspectives. Of most interest is the subject by subject analysis of numbers accepted for a degree course for the years 2002-2007. (Data for 2008 have not yet been published.) While ‘accepts’ are not necessarily the same as the number of entrants, they form a close approximation. Since 2002, UCAS and the Higher Education Statistics Agency (HESA) have used the same data definitions, so—where applicable—the entries refer to the same quantities<sup>2</sup>. From the UCAS data it is clear that the study of degrees named ‘Mathematics’ is by far the largest category, comprising more than 95% of the looser grouping.

Most of those accepted are also under the age of 20—at least 88%; and only about 15% come from overseas (whether EU or beyond). However, overseas numbers seem to be growing somewhat faster than home numbers, as is indicated in Figure 8. Home student acceptances in all age groups have been growing at about the same rate, except in 2006, where there was a substantial relative fall in numbers for those aged 20 and over. Of course, we only have data for 6 years, so it would be foolhardy to conclude too much about differential entry rates.

### 2.5 Undergraduate numbers

Data from HESA were also obtained, relating to the total number of undergraduates studying Mathematical Sciences (mostly Maths, but including Stats, OR and joint degree programmes), both full-time and part-time for the years 1996-2006. Unfortunately, these are not broken down by year of study, so how many of these were *entrants* during the year in question is not given.

<sup>2</sup>Unfortunately, published data from HESA often uses different categories from those used by UCAS, making the coincidence of definitions less useful than it might be.

## Mathematical Sciences - Undergraduate numbers

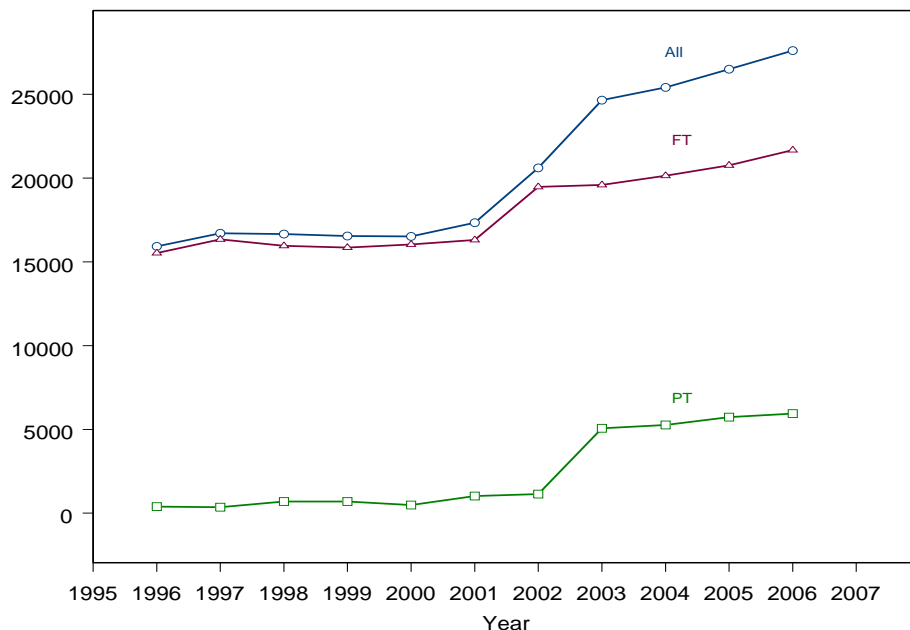


Figure 9: The number of undergraduates studying Mathematical Sciences (HESA).

HESA also publishes data relating to annual HE *graduates* in Mathematical Sciences. These numbers are clearly related to entrants 3 years earlier, but in the absence of knowledge of failure rates, converting these to entrants data is difficult.

Figure 9 shows the increase in numbers studying MS degrees since 1996. Since 2001 there has been a considerable increase in undergraduate numbers, notably in those studying part-time, which is about 15 times what it was 10 years ago. Full-time numbers have also increased, with the most interesting feature being a step-change of some 20% between 2001 and 2002. A study from the LMS [4] has shown there was a change in the classification methodology in 2002, and a re-classification of OR, which would partly account for this step-change.

However, more recent HESA figures also seem at odds with those given by UCAS: the total numbers studying a subject should not (*ceteris paribus*) exceed the sum of the previous 3 years' entrants. Indeed, given that some students will fail or withdraw for other reasons, the upper bound should be lower still. Yet the 3-year moving totals of UCAS 'accepts' for 2005 and 2004 (the only years for which sufficient data are available) are about 70% of the total number of full-time undergraduates studying MSOR in those years. Of course, some students undertake 4-year courses, but given the rather small numbers of such students, this could only explain a small part of the difference.

The LMS study has indicated some possible reasons for this discrepancy. In particular, HESA now apportiones students on combined degrees as 1/3, 1/2 or 2/3, depending on the relative importance of the elements of the degree. However, even if all those accepted to study some 'combined' form of MS and Computing—other than straight Computing subjects<sup>3</sup>—are included without *any* apportionment, the UCAS figures still only account for 92-96% of the HESA total for Mathematical Sciences. Thus it is still impossible to remove the discrepancy. In future, it may be sensible to concentrate explicitly on MSOR degrees, leaving the question of combined studies to the possible discovery of more comprehensive and compatible data.

<sup>3</sup>Individual Computing subjects listed are Computer Science, Information Systems, Software Engineering and Artificial Intelligence

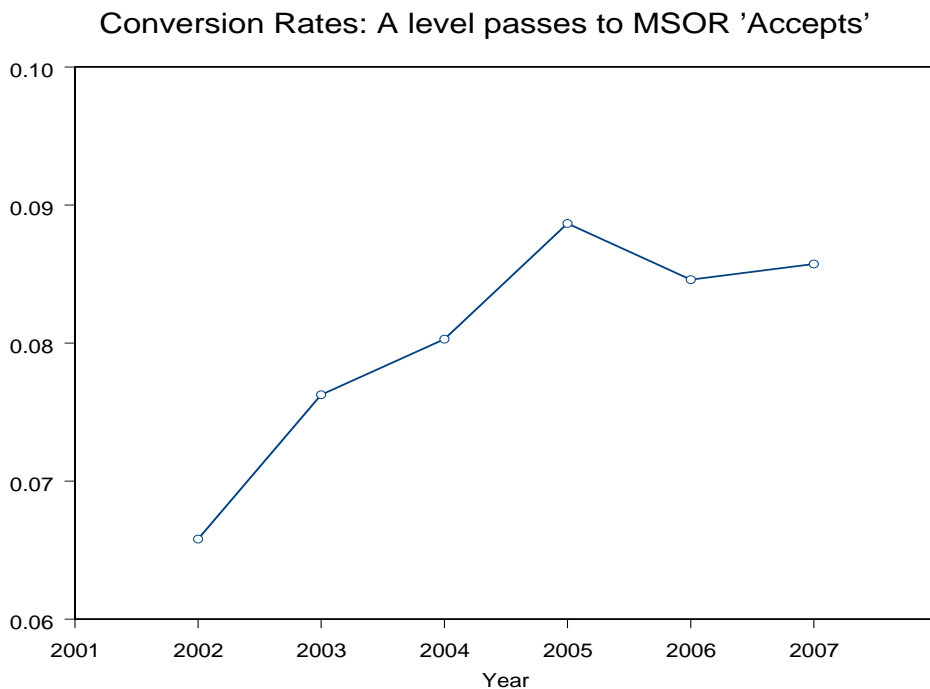


Figure 10: Estimated conversion rates of Home A level candidates into UCAS ‘accepts’ for undergraduate MSOR degrees.

A question of interest is how well students in the A level pool are being ‘converted’ into undergraduate study of MSOR degrees. Using the UCAS ‘accepts’ as a proxy for entrants, and restricting the comparison to Home students—those most likely to have entered by reason of A level qualifications—we have the conversion rates shown in Figure 10.

As indicated above, the number of *entrants* in each year is not available from publicly available HESA data for Mathematical Sciences. However, the number studying at any one time (ignoring fringe effects such as sandwich courses, 4-yr courses, retakes etc.) will be a fraction of those obtaining A levels in the 3 previous years. Thus a comparison of undergraduate numbers against the lagged 3-yr total A level pool should also provide a reasonable answer to the question of conversion rates. This has been done in Figure 11.

Although only 5 points can be plotted for this graph, and 6 for Figure 10, both provide some evidence of improved conversion rates over the last few years, although this may be confounded with the definitional changes previously mentioned. Given that the HESA definition of MS appears wider than that used by UCAS, it is not surprising that the rates in Figure 11 are higher than those of Figure 10. It is encouraging that an upward trend is apparent in both, although the most recent figures suggest this might be flattening out.

## 2.6 Graduate numbers

The 66% increase in undergraduate numbers indicated from HESA sources (ignoring for the moment the definitional problems) has resulted in a less substantial increase in graduates (even allowing for lags), but the numbers are still about 50% higher than those of 10 years earlier. (AGain, 2008 figures are not yet available.) Figure 12 displays the data.

This suggests that failure and withdrawal rates have increased, but in the absence of relevant data, the underlying causes for this remain speculative.

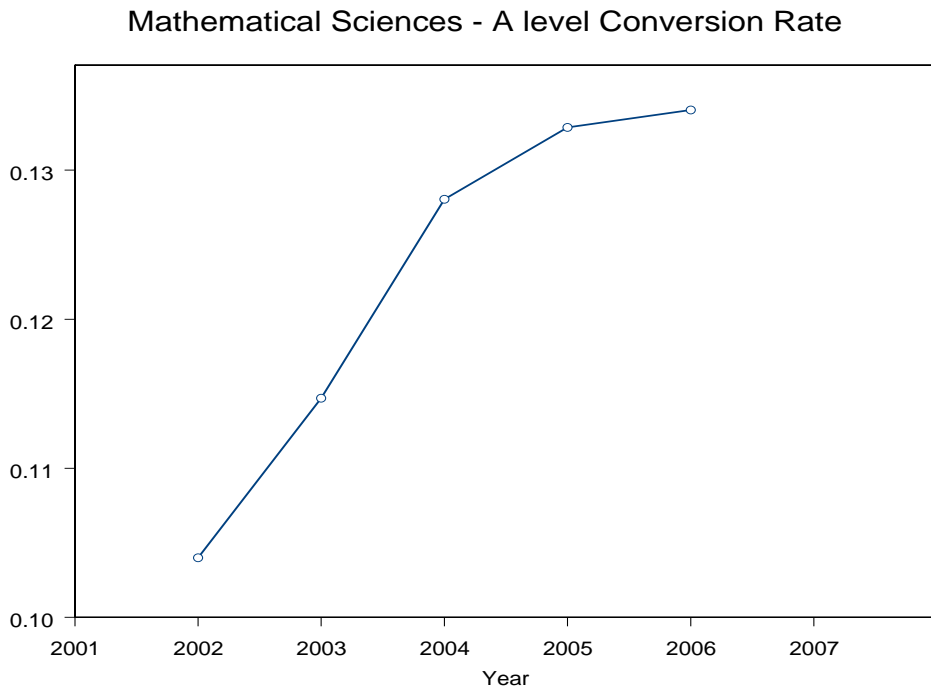


Figure 11: Estimated conversion rates of Home A level candidates into undergraduate study of a MS degree, using HESA data.

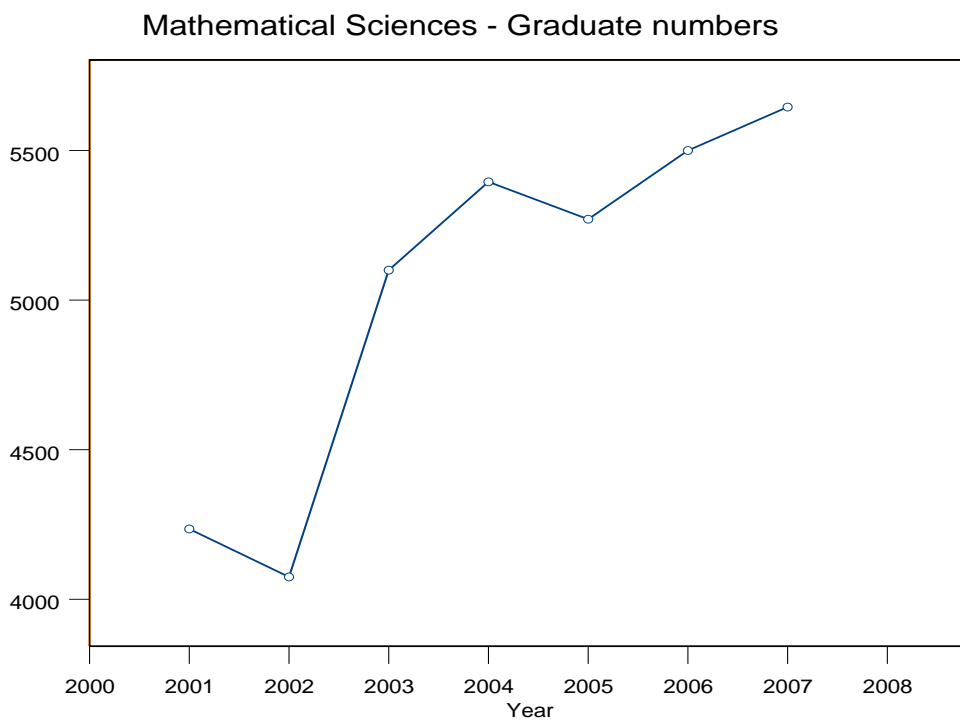


Figure 12: The number of graduates in Mathematical Sciences (as defined by HESA).

### 3 Conclusion and Further Work

It has been possible to ascertain in broad terms the current numbers and trends for HE Mathematical Sciences students, but paucity of data and the use of inconsistent definitions and/or categorisations make it difficult to uncover more details in the picture.

Firstly, it is clear that the introduction of Curriculum 2000 was catastrophic for Mathematics A level studies. Neither aggregate numbers nor participation rates have yet recovered to 2001 levels.

Nonetheless, in Mathematical Sciences as a whole, numbers of A level students, undergraduates, and graduates (with a *caveat* concerning definitions in the latter two categories) are all growing: we *are* getting ‘more Maths grads’, so from the perspective of the MMG initiative, we are already doing something right. Notwithstanding this overall increase, it is rather worrying that the proportion of girls studying A level Mathematics remains substantially lower than the corresponding number for boys. It is also somewhat baffling that this discrepancy increases after AS level, despite the better performance of girls at this stage.

The analysis reported above has focused on UK A level aggregate statistics, and is by no means exhaustive. The numbers on Mathematics degrees in the narrow sense could quite easily be investigated. Analyses of England data, for example, could also be undertaken, but a preliminary analysis suggests that the situations in Wales and N.I. are insufficiently different (and the numbers insufficiently significant) for this to be relevant.

There is clearly scope for much further analysis, but analysis for the sake of it should of course be avoided. This report will be updated in 2009, following the latest release of JCQ, UCAS and HESA data. As the MMG project draws towards a close, some data have also been promised that are specific to the schools visited by the project. Neither the amount nor the quality of the data seen so far are ideal, but it should be possible to draw some conclusions regarding the effectiveness of the project’s interventions in these schools.

### References

- [1] <http://www.jcq.org.uk/press%5Freleases/results/>  
(last accessed 26/11/2008)
- [2] <http://education.guardian.co.uk/alevels/story/0,,2149312,00.html>  
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- [3] <http://www.fmnetwork.org.uk/index.php>  
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- [4] S.Wydall (2005) *HESA Mathematics Definitions*. London Mathematical Society, unpublished report.