Science and Technology Committee: Spending Review 2010 submission by the Council for the Mathematical Sciences

About the Council for the Mathematical Sciences (CMS)
The CMS (www.cms.ac.uk) was established in 2001 by the Institute of Mathematics and its Applications (IMA), the London Mathematical Society (LMS) and the Royal Statistical Society (RSS). They were joined in 2008 by the Edinburgh Mathematical Society (EMS) and the Operational Research Society (ORS). The CMS provides an authoritative and objective body that exists to develop, influence and respond to UK policy issues that affect the mathematical sciences in higher education and research, and therefore the UK economy and society in general.

- The IMA is the UK's learned and professional society for mathematics and its applications and has around 5,000 members.
- The LMS was founded in 1865 and has as its purpose the advancement, dissemination and promotion of mathematical knowledge in the UK and worldwide.
- The RSS, founded in 1834, aims to nurture and promote statistics, encouraging statistical knowledge and disseminating good practice in society at large.
- The EMS was founded in 1883 and has around 450 members. Its aims are the promotion and extension of the Mathematical Sciences, particularly in Scotland.
- The ORS is the world's oldest-established learned society catering to the Operational Research profession, with 3,000 members in 53 countries.

<u>SUMMARY:</u> UK mathematical sciences research is excellent on an international scale, and its high quality crucially depends on the diverse and distributed nature of the research community: over 1100 staff FTE of world leading or internationally excellent research from 56 different institutions were submitted to RAE2008. Mathematical Sciences underpin our 21st century technology, economy and society, and this is recognised in the employment market, where our graduates are in extremely high demand. However, EPSRC funding in mathematical science has decreased significantly in real terms over the past decade, to the point where current funding levels threaten the health and continued excellence of the discipline. There are potentially severe consequences of the reduction or concentration of core Research Council support to mathematical sciences, including the loss of productive relationships between companies and their local mathematical science departments, and a reduction in the number of highly-skilled mathematical science graduates. This has potentially profound consequences for business, for industry, and for education.

A. MATHEMATICAL SCIENCES: RESEARCH

1. CMS (Council for the Mathematical Sciences) welcomes the opportunity to provide written evidence on the Spending Review 2010. The term *mathematical sciences* encompasses pure, applied and applicable mathematics, including statistics and operational research. They constitute fundamental scientific disciplines in their own right, but also provide languages, theories and tools for every field of engineering and science and impact on fields such as economics, psychology, sociology, medicine, and many others.

2. As stated in the 2010 International Review of Mathematical Sciences commissioned by the EPSRC[1], *Major contributions to the health and prosperity of society arise from insights, results and algorithms created by the entire sweep of the mathematical sciences, ranging across the purest of the pure, theory inspired by applications, hands-on applications, statistics of every form and the blend of theory and practice embodied in operational research.*

3. Current mathematical sciences research has a substantial impact on UK society. For example, statistical epidemiologists are adapting containment and treatment strategies for pandemic influenza in preparation for potentially more serious strains of H1N1. Pure mathematicians work (necessarily unpublicised) on crucial areas of national security at the Heilbronn Institute, funded by GCHQ. In energy, new mathematical models and numerical algorithms are improving both the efficiency of oil and gas extraction as well as the operation of renewable and traditional energy markets. In finance, sound quantitative risk management will be essential for developing effective regulatory procedures. The IMA has recently produced a set of case studies to illustrate some of the many ways that mathematics research impacts on contemporary society[2].

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[1] International Review of Mathematical Sciences, draft report presented on 28 January 2011, available from www.cms.ac.uk/activities.html

[2] Mathematics Matters case studies, Institute of Mathematics and its Applications, www.ima.org.uk/i_love_maths/mathematics_matters.cfm

4. Page 12 of the BIS funding allocation document[3] states: *Our policy is to concentrate funding further on research centres of proven excellence, so these centres have the critical mass to address national challenges and compete internationally.* Such **research concentration** may be appropriate for some academic disciplines, but it is **not appropriate for the mathematical sciences,** as research excellence is currently widespread (ground-breaking research in mathematical sciences is often undertaken by individuals and very small groups) and further concentration would not be beneficial. Any proposed additional concentration would have a negative effect on both education and on industrial support. Indeed, two of the main findings of the recent International Review of Mathematical Sciences[1] are that (with our emphasis): *Overall, mathematical sciences research in the UK is **excellent on an international scale***, and that *the high quality of UK mathematical sciences research **depends critically on the diverse and distributed research community**, where `diverse' includes research area, group size and institution size, and `distributed' refers to geographical location*.

5. For this reason we welcome Professor David Delpy's answer during his Select Committee appearance[4] that: ***Critical mass and concentration is relevant in a large part of our remit but not in every subject***.

6. The wide geographic distribution of excellent mathematical sciences research is demonstrated by Table 1, giving the volume of research rated as world leading (4*) or internationally excellent (3*) in RAE2008. The corresponding figures for physics and for chemistry are included for comparison. (The figures for each row are calculated by multiplying the output percentage in these quality bands by the number of academic staff in each RAE submission, and adding over all submissions.)

Unit of Assessment (UoA)	No. of institutional submissions	3*– 4* research in RAE2008 (staff FTE)
Chemistry (UoA 18)	33	737
Physics (UoA 19)	42	957
Mathematical Sciences (UoAs 20-22)	57	1129

Table 1: academic staff FTE of 3* and 4* research from RAE 2008

B. MATHEMATICAL SCIENCES: EDUCATION

7. The **size and importance** of the discipline is evident at the **undergraduate level**: with 5475 graduating students in 2007/08, the mathematical sciences undergraduate cohort is nearly the same size as those for chemistry (2965) and physics (2765) combined. Figure 1 on the following page shows the number of first degree qualifications obtained by UK students in mathematics and physical sciences over the last 25 years.

8. **Mathematical sciences graduates are in high demand** in the UK economy, as shown for example by starting salaries. Table 2 below shows the average salary of undergraduates and postgraduates six months after graduation in 2007/08.

Subject	First degree	Postgraduate (ex PGCE)
Biological Sciences	£16,500	£22,500
Physical Sciences	£19,000	£24,000
Computer Science	£21,000	£24,000
Engineering & technology	£23,000	£25,500
Mathematical Sciences	£22,500	£27,000

Table 2: average salary of undergraduates and postgraduates six months after graduation in 2007/08[5]

[3] Department for Business Innovation & Skills, "The allocation of science and research funding 2011/12 to 2014/15", December 2010
[4] Oral evidence taken before the Science and Technology Committee: Spending Review 2010 (19 January 2011), Q150
[5] Taken from the table on p 94 of Adrian Smith's report *One Step Beyond: Making the most of postgraduate education* (March 2010)

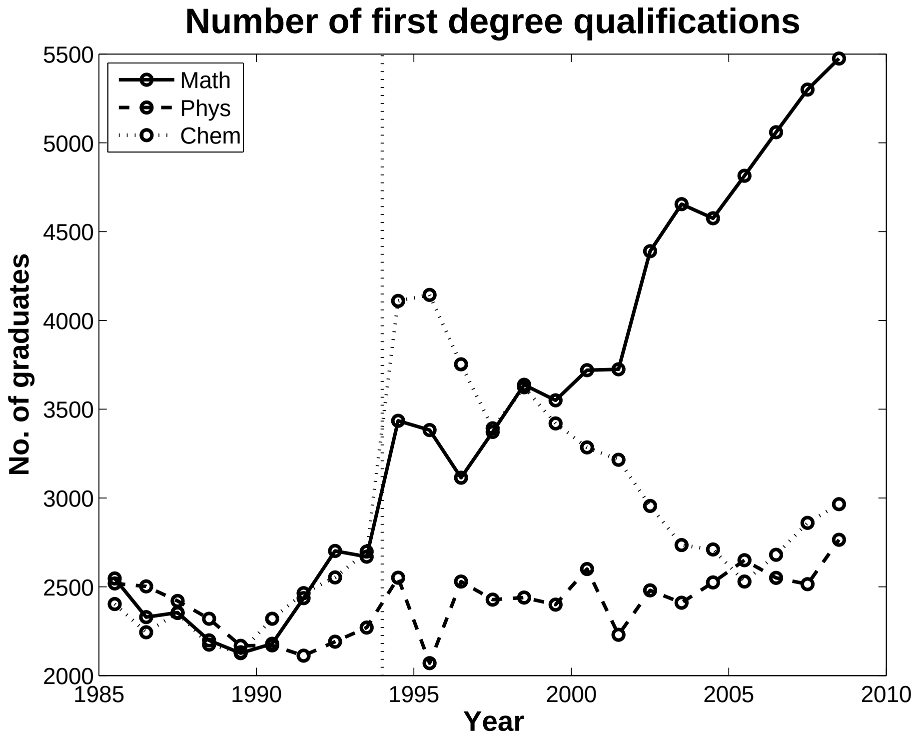

Figure 1: number of first degree qualifications obtained by students at universities in mathematics, physics (including astronomy) and chemistry from 1985/86 to 2008/09. The data up to 1993/94 relates to universities only and does not contain any data for polytechnics (shown by the vertical dotted line)[6]

9. Even with such a large graduate cohort there is a **severe lack of qualified mathematics teachers**. Figures in a recent Royal Society report[7] show that only about 2% of primary teachers in England have a specialist mathematical science qualification (fewer than one for every four primary schools). An earlier RS report[8] estimated that there were 21,126 mathematics teachers (including 11,652 who have a mathematical sciences degree, or about 55%) in English secondary schools. DfE data on the shortfall in mathematics teacher recruitment is tabulated in another RS report[9] and graphed in Figure 2 below.

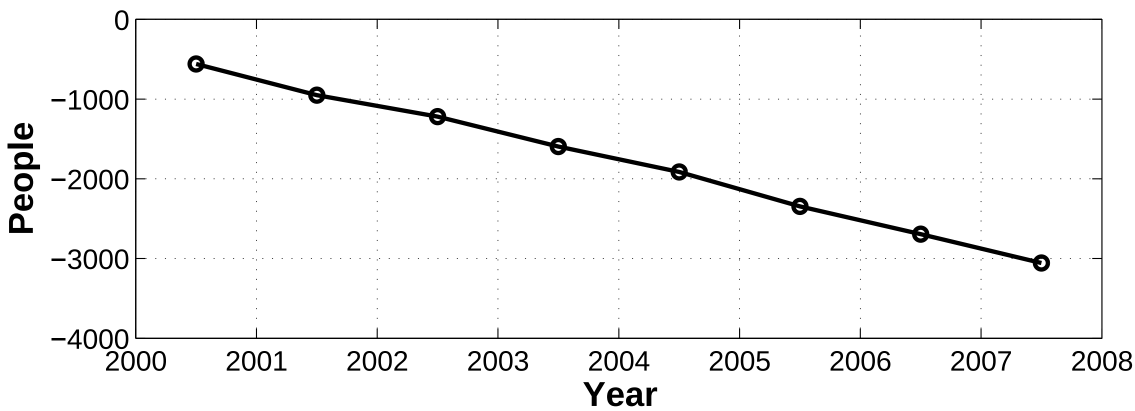

Figure 2: cumulative shortfall in meeting mathematics recruitment targets, 2000/01 to 2007/08[9]

[6] Data (originally from the Higher Education Statistics Agency, HESA) taken from www.iop.org
[7] Science and mathematics education, 5-14, The Royal Society, July 2010
[8] The UK's science and mathematics teaching workforce, The Royal Society, 2007
[9] The Scientific Century: securing our future prosperity, The Royal Society, 2010

C. MATHEMATICAL SCIENCES: RESEARCH FUNDING

10. Contrasting with the strong performance in research and education outlined in sections A and B, CMS wishes to draw attention to the **very low levels of research funding** in mathematical sciences. A high proportion of Research Council support for the mathematical sciences is provided by the EPSRC. Table 3 lists EPSRC's published "research grant commitment by programme" from 2002/03 to 2009/10.

Programme /Year	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	% change (7 years)
Mathematical sciences	**9**	**11.7**	**16.2**	**16.4**	**21.5**	**24.2**	**15.3**	**12.0**	**33%**
Information and communications technology	**44**	**63.6**	**80.4**	**88.8**	**87.2**	**83.3**	**75.6**	**72.0**	**64%**
Physics	26	32.0	39.1	38.2	49.2	33.1	-	-	
Chemistry	26	46.1	42.7	48.2	51.7	42.8	-	-	
Physical sciences	-	-	-	-	-	-	100.4	88.0	
Subtotal: Physical sciences	**52**	**78.1**	**81.8**	**86.4**	**100.9**	**75.9**	**100.4**	**88.0**	**69%**
EPSRC total	**259**	**378.0**	**435.2**	**490.6**	**621.5**	**537.5**	**548.4**	**459.0**	**77%**

Table 3: EPSRC research grant commitment by programme (in £m)[10]

11. Table 3 shows that EPSRC's total research grant commitment has increased by 77% during the seven year period 2002/03 to 2009/10. This increase includes a uniform uplift of 45% because of the introduction of full economic costing (fEC) in April 2006. Note however that the corresponding increase for mathematical sciences is only 33%, which when the fEC uplift and inflation are factored in, **represents a large cut in research grant commitment in mathematical sciences**.

12. We note also that the overall level of EPSRC support in the **mathematical sciences is very low compared to disciplines such as chemistry and physics**. This is in spite of the excellent research performance and substantial educational contribution outlined in Sections A and B respectively, both of these being of crucial importance to the long-term scientific, industrial and economic performance of the UK. Figure 3[11] below clearly shows that this is not predominantly because of higher equipment costs for experimental sciences – the fact is that far fewer staff are funded in mathematical sciences than in other major disciplines. The very low number of funded postdoctoral positions has profound consequences for the future health of the discipline, as we discuss below.

D. CONCLUSIONS

13. There are **potentially severe consequences of the reduction and concentration of core Research Council support to mathematical sciences**. The most immediate threat is that of a decline in the amount of internationally excellent research in the mathematical sciences produced in the UK. Some other less obvious consequences are described below.

14. The "**pipeline problem**": given the very low numbers of postdoctoral positions, it is difficult for UK-educated PhD students to gain enough research experience in order to compete for academic posts. The International Review[1] panel *regards this fragility as a serious potential risk to the UK's future international standing* in mathematical science. While mathematical science is an international subject, so that UK departments have been able to recruit excellent staff from around the world (in most but not all fields), there are risks stemming from this solution: a lack of stability, and a possible shortage of role models for undergraduate mathematical scientists.

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[10] Taken from the tables called *Research grant commitment by programme* from the EPSRC annual reports from 2002/03 to 2007/08 and *Research grant investment by programme* for 2008/09 and 2009/10

[11] EPSRC data

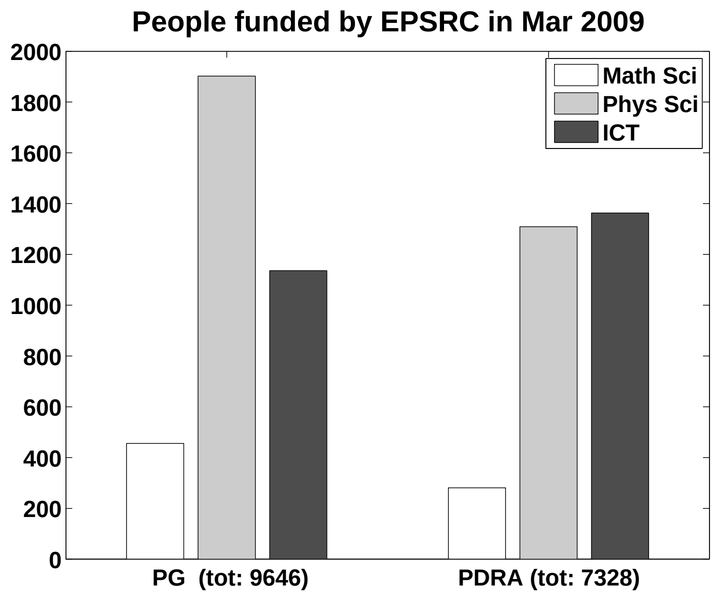

Figure 3: number of postgraduate students (PG) and post doctoral researchers (PDRA) funded by EPSRC as of March 2009 in mathematical sciences, physical sciences, and information and communications technology

15. Although it is government policy to concentrate research[3], it is not government policy that industry and commerce should be concentrated: indeed the opposite is required. However, research concentration could lead to **the loss of productive relationships between companies and their local mathematical science departments**, together with a narrowing of the supply of research advice, interns and knowledge transfer. The movement of new PhDs into industry and commerce is one of the best forms of knowledge transfer, a process which currently works well at both local and national levels.

16. **Unintended consequences of current policies:** Advanced undergraduate teaching in mathematical science is necessarily "research informed". Faced with reduced research council funding, departments will shrink or even close: there is already anecdotal evidence from several of the large English mathematical sciences departments that their universities are preferentially choosing to hire staff in `big science' disciplines where there is the potential to bring in large amounts of fEC funding, rather than mathematical sciences where RCUK funding levels are low. Cutting the research base in this way may **reduce the number of highly-skilled graduates** available to industry and as teachers, particularly at a time when large fee increases could cause more undergraduates to study close to their parental home.

27 April 2011