COUNCIL FOR THE MATHEMATICAL SCIENCES

The Institute of Mathematics and its Applications | The London Mathematical Society | The Royal Statistical Society

Secretariat: Martin Smith, De Morgan House, 57-58 Russell Square, London WC1B 4HS
email**: cms@lms.ac.uk** tel: 020 7927 0803

Science Consultation
c/o Fiona Mackay
Bay 365
Office of Science and Technology
1 Victoria Street
London
SW1H 0ET

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Dear Ms Mackay

Science and Innovation investment framework 2004-1014: next steps

The Council for the Mathematical Sciences, comprising the Institute of Mathematics and its Applications, the London Mathematical Society and the Royal Statistical Society, is pleased to enclose its response to *Science and innovation investment framework 2004-2014: next steps.* This response has been prepared by a working group consisting of representatives from the three societies as part of the Council's ongoing role of representing the interests of the mathematical sciences to government and other public bodies.

The Council welcomes the continuing commitment of the government to investment in science and innovation. The pervasive effectiveness of Mathematics means that it plays a pivotal role in each of the five key policy areas signalled in the executive summary.

However, some of the proposals appear to underestimate the scale of the problem, particularly with regard to the mathematical sciences. While the proposed measures to increase the uptake of science at A-level and beyond are helpful, we believe they are far too limited. A broadly-based, scientifically-educated, workforce is the essential foundation for a knowledge economy. Mathematics is the key component, not least because it underlies the technology behind such things as mobile phones, digital cameras, and personal computers, which many people take for granted.

We would have expected to have seen stronger measures proposed, including scaled tuition fees for students taking shortage subjects and an increase in the HEFCE unit of resource for mathematical subjects. The steady erosion of the mathematics base in HE can only be halted by funding that reflects actual costs, and recognises that teaching advanced mathematics is a labour-intensive activity.

Our more detailed response is arranged according to the seven discussion questions on page 51 of the document and is appended to this letter. The principal recommendations are as follows.

1. Reduction or removal of tuition fees for strategic shortage subjects such as mathematics, to further encourage post-16 participation.
2. Recognition that research in mathematics is intrinsically risky, and that risk is not only characterised by cross-disciplinary working.
3. Funding of ambitious landmark projects in mathematics and statistics, with large pay-off in terms of the profile of the disciplines and potential impact in other fields.
4. Training in innovation and business skills available for all scientists and engineers.

5. Access for SMEs to national research resources, such as high performance computing.
6. Better incentives for universities to engage in knowledge transfer.
7. Research council funding to bridge the gap between scientific innovation and exploitation, particularly in terms of statistical methodology.
8. Increased funding for career progression, including more PhD studentships, and more postdoctoral and mid-career fellowships in mathematics and statistics.
9. Reconsideration of plans to replace the current RAE evaluation by a metrics-based system, so that all statistical relationships are subjected to peer review and existing RAE evaluation is retained for units of assessment in which metrics are insufficiently predictive.

Yours sincerely,

Professor J F Toland FRS

Chair, Council for the Mathematical Sciences

COUNCIL FOR THE MATHEMATICAL SCIENCES

Response to *Science and innovation investment framework 2004-2014: next steps*

1. The Government would be interested in views about whether the existing framework for supporting science and innovation enables an appropriate level of risk-taking, and if not, suggestions of how any gap might be addressed.

Research in the mathematical sciences is essentially people intensive; the best way of encouraging risk taking is to identify good people and give them time to pursue exciting and innovative ideas without the pressure of other academic commitments or the requirement to deliver a guaranteed quantity of research to a prearranged timetable. Industry itself wants such "blue skies" alternative thinking, recognising that it cannot itself support this, or take a medium or long term perspective.

Timeliness and adventure are both essential within a balanced research and development portfolio and do not in our opinion compromise, or contradict, excellence (they are distinct measures – partly correlated) and longer-term vision and delivery of both people and knowledge. There is perhaps a problem in that we have a large amount of "excellence" to fund across all of science and technology – and all of the research communities will tend to protect what they have and resist a decrease in, say, general responsive mode funding in favour of more risky topics. However this barrier is about culture more than anything.

In mathematics, risk is involved in much academic research, because it is generally quite speculative at the outset: if a researcher knew at the beginning that a theorem was true (or indeed how to state it) it wouldn't be research. It is important that research of this nature, for which Gantt charts and lists of milestones may be an inappropriate format, is supported both in responsive mode project funding and in the support of individuals.

Risk taking should be clearly and appropriately defined within each research council (sub) programme – for example risk-taking in mathematics, highly speculative work but with high possible impact, is (perhaps) mostly about radical theory rather than about applications.

The OST should not demand that risky or adventurous research be multidisciplinary in nature (as it does, by definition, for almost all current innovation and exploitation initiatives).

In mathematics, long-term commitment to adventurous topics may be best achieved though an increase in mid-career fellowships, for "stars" to develop radical research agendas.

Whilst many initiatives at the RCUK level have been funded because of multidisciplinary needs, it should also be recognized that success within theoretical sciences, such as mathematics, creates a climate of achievement and innovation (in its usual sense) and can therefore act as an attractor for both corporate and personal investment of resources and time into the UK.

A possible route which we would like the DTI to consider is that it invests in some one-time theory-based landmark activities. For example it might create a core of world leading problem-centred mathematical research activity designed specifically to

- Increase the international competitiveness of UK mathematics, so as to go beyond other countries in our achievements;
- To inspire younger mathematicians through the mathematical achievements of the UK community;
- To increase the esteem in which mathematical achievement is held by the public, industry, and by opinion formers within the UK and abroad.

The aim would be to create new, or renew momentum in, very high profile fields and attack some specific internationally known problems. The resolution of the problem is not the necessity: it is the ambition and excellence of the mathematical journey that is the most important thing, not the final destination. Like previous activities in the US or Canada, for example, these projects should be envied elsewhere in the world, and become landmarks or flagships in the public and opinion formers' minds, and provide an inspirational affirmation of the importance of mathematics to the UK and its future.

In statistics, landmark activities would be less concerned with fundamental unsolved problems, but more with the ambition to tackle big questions such as the analysis of microarray data, phylogenies, palaeoclimatology or carbon accounting. All of these require highly sophisticated statistical modelling and massive computation, with enormous potential impacts, but they are seriously hard problems. Our current research council structure is inadequate to fund this work properly, because it does not fit the EPSRC Mathematics remit (being too applied) yet is seen by other research councils as being research in statistics (and so not in their remits, either).

2. The Government invites views on measures to remove any remaining bias which unfairly favours established research fields over innovative ones. The Government also invites views on how funding mechanisms can be made more responsive to new research challenges.

3. The Government would welcome views on the barriers limiting greater business innovation and business-university collaboration in the regions, and on what more could be done on a national and regional level to tackle these barriers effectively.

For the longer term, the HEIs should be encouraged (in some way) to include as an option some training covering innovation and business skills on all degree courses for all engineers and all scientists – especially including theoretical and basic subjects like mathematics, where there is the most to gain. Basic know-how about exploitation, investment capital, company formation, corporate strategy, business planning, market positioning, marketing and alliance development are all things that should be taught to science and technology undergraduates. Pilot final year modules should be introduced as soon as possible.

Much more needs to be done for the independent SMEs. For self-funded, or venture capital funded, SMEs with say 10 to 100 employees, there is a need to create (tensioned) access to the central facilities (HPC, grid, test beds, lab facilities and data resources: bioinformatics databases, biobank, geo/mapping info etc.), as well as the associated user expertise (that mostly resides within universities). SMEs would then be able to access these in the same way as university researchers might access such resources on research council funded projects, or through local access within universities. For example, suppose there are consulting and services SMEs (boutiques) with specific mathematical simulation and/or modelling competences (in such areas as the environment, security, defence, service or media). They may have codes that could be ported onto HPC facilities to provide demonstration and benchmarking collateral, which would help them expand abroad (providing more options to potential clients, or state of the art differentiation by exploiting the central facility). They would require help from existing (university/HEI) users and experts to port their code and run jobs. Currently they cannot easily get the access which is readily available to university groups and spinouts.

Should we facilitate innovative links to the new economies such as China, South America and Africa? It cannot be just left to undergraduate migration (which is indeed growing very rapidly) – it should include postgraduate and research level interactions. What we might need are partnerships between their own universities/HEIs, local to those economies, and a UK HEI, with a track record of supplying research, trained people, service, and know-how from relationships within the UK and EU. For example, having foreign PhD students spend half time in their own HEI and half time in the UK would build strong links at little cost; Loughborough University already does this in mathematics. In fostering such twinning relationships between universities at home and abroad (where the parties take a deeper interest in the partner's local attributes, history, and environment) the UK government should place the mathematical sciences in the vanguard, with funds made available for student exchanges at both undergraduate and graduate levels. This is because almost all such investment in mathematics goes directly into the people. (There is a relatively modest need for infrastructure and equipment in mathematics.) Mathematical development and expertise within the emerging economy may be already at such a level of achievement to make the interaction fruitful as a two way street. Therefore one can leverage the existing contacts and use small amounts of money to build collaboration with substance.

From the university side the missing element is proper incentives. There can be almost no RAE benefit in getting involved in industrial collaboration and, unless FEC are paid, little direct financial gain. Schemes such as KTP do not really address this. Also, it would be good if there was some incentive for

universities to invest effort in technology transfer which might be of benefit to a number of businesses, but which would be insufficiently mission critical to be funded by a single business. If the Government is serious about these issues, then funding streams for these kinds of activity (or equivalently incentives for business to invest their own funds at the required level) will need to be more readily available.

There is an important disconnect in research funding between blue skies research and exploitation. In the mathematical sciences, much of our research is essentially blue skies, and the mathematical sciences programme of EPSRC has rightly taken the view that with its limited funding it must support high quality core research as its top priority. A proportion of this research has potentially wide-ranging, generic applications. In statistics, it may be relatively easy to predict these potential impacts. However, it is not possible to get industry funding to exploit them, because at the point where EPSRC funding ceases they are too far from being the nice packaged tools that industry wants.

Work so often needs to be done to convert the pure science into commercial products. This is not the case to the same extent in engineering and the laboratory sciences. Even where this kind of development phase is recognised in those disciplines, as it is in the biotech world, industry is prepared to invest in the development process because it has a clear appreciation of the potential benefits. In the mathematical sciences, this development phase still needs advanced skills and is still risky, but it gets no pay-off in the RAE, cannot get funded by EPSRC and does not attract industrial input. There is a very clear need for the Maths Programme's remit to be extended to fund this per-exploitation phase, with an enhanced budget to do so. Indeed, just as the user interface takes at least four times as much resource to develop as the computational engine in any commercial software, so this pre-exploitation work often requires more funding than the original EPSRC research grant.

For the science budget to take responsibility in this way for such development would not only make it easier to bring UK innovation to market, it would also flag promising mathematics and statistics research clearly to industry. More importantly, it would encourage researchers to engage more with bringing their ideas to commercial fruition by making such research RAE worthy.

Extending the range of support into these areas must be by allocating additional funding for mathematical research.

4. The Government would welcome views – in particular from outside Higher Education - which can be taken into account in developing best practice models for business university collaboration. In addition, the Government would welcome views on how to encourage businesses to work with universities for the first time, perhaps by introducing short-term, low-cost mechanisms for business-university interaction.

Larger companies can reposition and reinvent themselves around their key assets – their existing customers, their existing vectors to reach them, their responsiveness, and their infrastructure – rather than necessarily extending or even continuing their current activities, services, and products. Larger companies have the access to these assets but their R and D staff are busy – so they could acquire or co-develop new IP (sharing risk return) with the HEI. This means that within an innovation agenda we have a mechanism that might foster relationships between companies within the UK where previously there has been little synergy or communication, particularly in the service and customer facing sectors.

5. The Government would welcome views on whether all large facilities operations should be integrated under a new Large Facilities Council, or whether there is a case for some facilities to remain under the management of other Research Councils.

6. Furthermore, in the event of a merger, should the grant-giving functions of PPARC be moved to EPSRC?

This proposal would appear to have the unfortunate effect of splitting the support for the large facilities from the support of some of those who work in them.

7. The Government would welcome views on what further measures could be taken by the Research Councils to improve their effectiveness

Research councils play an absolutely vital role and are generally effective within the limits of their budgets. An obvious suggestion is a further increase in funding levels, since even after recent increases financial constraints restrict activity in a damaging way.

For example, there is still insufficient funding to ensure good career progression for research mathematicians. The recent international review of mathematics carried out by the EPSRC made it clear that that support for young mathematicians would be vital if Britain is to maintain its international position. At the postgraduate level there is insufficient funding for PhD students, and a lack of joined-up thinking with HEFCE, for instance to investigate whether Teaching Assistantships, common in many other counties as a method of support for those reading for PhDs, would be a useful mechanism. The introduction of tuition fees for undergraduate studies is likely to be a serious discouragement to potential PhD students if the studentship package does not include repayment of student loans. Additionally, while EPSRC has an excellent programme of postdoctoral fellowships for recent PhD graduates, but there are far too few of these to ensure that the population of research mathematicians is maintained.

Currently EPSRC PhD support via DTAs is restricted to EU students, with full support only for UK students. This policy should at least be reviewed, as there are obvious benefits from supporting all PhD study in strategic subjects by talented individuals if successful students are then encouraged to remain in the UK.

There is a clear need for more cooperation across the research councils in funding research in statistics. Such measures as are in place are too informal, too haphazard, and are managed at too low a level in the councils.

There is widespread concern in the mathematics community about the proposal to use metrics for the Research Assessment Exercise. It is important that the distinctive features of mathematics are appreciated, which make it inappropriate to treat it in the same way as other STEM subjects. It seems unlikely that a metric constructed from available numerical data, be it grant volume, publication output, citations or whatever, will reliably reflect quality. Moreover the use of metrics may distort activity in unhelpful ways as people adjust behaviour with a view to raising some score. It can easily lead to ossification of the funding model, and make it difficult for emerging talent to be recognised.

There are particular concerns about the use of grant volume as a significant element of any metric, since this might undermine the very purpose for which the RAE was set up. This was to provide support for people as part of the dual support system, recognising that a contribution to the core funding for academic staff should be research based rather than simply student based, so that the vital element, academic staff time spent on research, could be properly funded. With full economic costing, staff implications of research activity supported by a grant should already be covered. Areas of mathematics which do not normally require research grants might be relatively disadvantaged for accidental reasons. The EPSRC's own figures apparently indicate that there is little correlation between grant volume and other measures of esteem.

If metrics are to be used, then (a) the creation of these metrics must be open to peer review, particularly by skilled academic statisticians, and (b) any discipline/UoA for which the quality of fit falls below some threshold cannot be judged in the next RAE on metrics alone, but must instead have a panel to provide some independent quality judgements.

Finally, we wish to emphasise concern at the proposed measures to increase uptake of A level sciences. One measure that would have much more effect would be to abolish university tuition fees for the sciences. This is within the government's power, is entirely in keeping with the golden handshakes and other inducements for science teachers, and need not be very expensive. If necessary, it could be funded by an increase in fees to other disciplines.