Making mathematics impactful – why it matters and how to achieve it

Knowledge Exchange and the Mathematical Sciences.

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Why it REALLY matters

Why does impact matter ?

- We all want to live in a fair and free society.
- We want cleaner air to breathe, to use greener energy, and to ensure that we have a planet that is habitable in 100 years time.
- We want to have healthy lives, be defended from threats and live with dignity.
- We want to communicate with a huge number of people yet maintain and control our privacy.

Why does impact matter ?

- In short, we want to have rising standards of living achieved in a sustainable way. That means doing more with fewer resources.
- So what creates a rising standard of living ?
- and, as a nation, how is ‘UK PLC’ doing in this respect ?

Productivity and Standards of Living

- Paul Krugman, Nobel Prize in Economics 2008.
- ‘Productivity isn’t everything but in the long run it is almost everything’.

UK productivity shortfall with the G7 relatively stable.

Current price GDP per hour worked

On this basis

US productivity was 28 % higher than the UK and 40 % higher on a per-worker basis.

French productivity was 28 % higher than the UK.

German productivity was 30 % higher than the UK.

So how do we expect to have comparable living standards ?

Productivity and Innovation

- Roughly speaking, 50 % of the increases in productivity that occur are due to two related factors : the development of innovations and the uptake of innovative technologies.

- So if we want to have a rising standard of living – and hence pay for healthcare, defence, pensions, carbon taxes, and so on – we need to become far more innovative and far more effective at driving innovation into the economy.

- UK productivity growth flatlined after 2008 and is still looking subpar.

The Industrial Strategy Challenge Fund

- Currently around £1.7 Billion
- Original intent – to drive impactful research into industry in order to gain a strategic advantage.
- Original focal point – AI and Robotics.
- Proposed by the Prime Minister's Council for Science and Technology.

Core CST Recommendations

- **Identify challenge areas of economic opportunity and national significance for the UK to improve focus and encourage collaboration**.

- ***We recommend that the challenges should run along the lines of the US DARPA using a cross-cutting X-ARPA***. DARPA challenges have several key features : effective problem definition ; outstanding programme management ; demanding timescales ; openness to a wide range of entrants, including SMEs ; a culture which encourages collaboration and creativity but also accepts the possibility of failure ; and arrangements for participants to access high quality facilities.

The Era of Mathematics

- We live in the Era of Mathematics.

- Virtually every new technology relies (often in a way that is ‘hidden from sight’) on mathematics.
- That includes ‘management as a technology’.

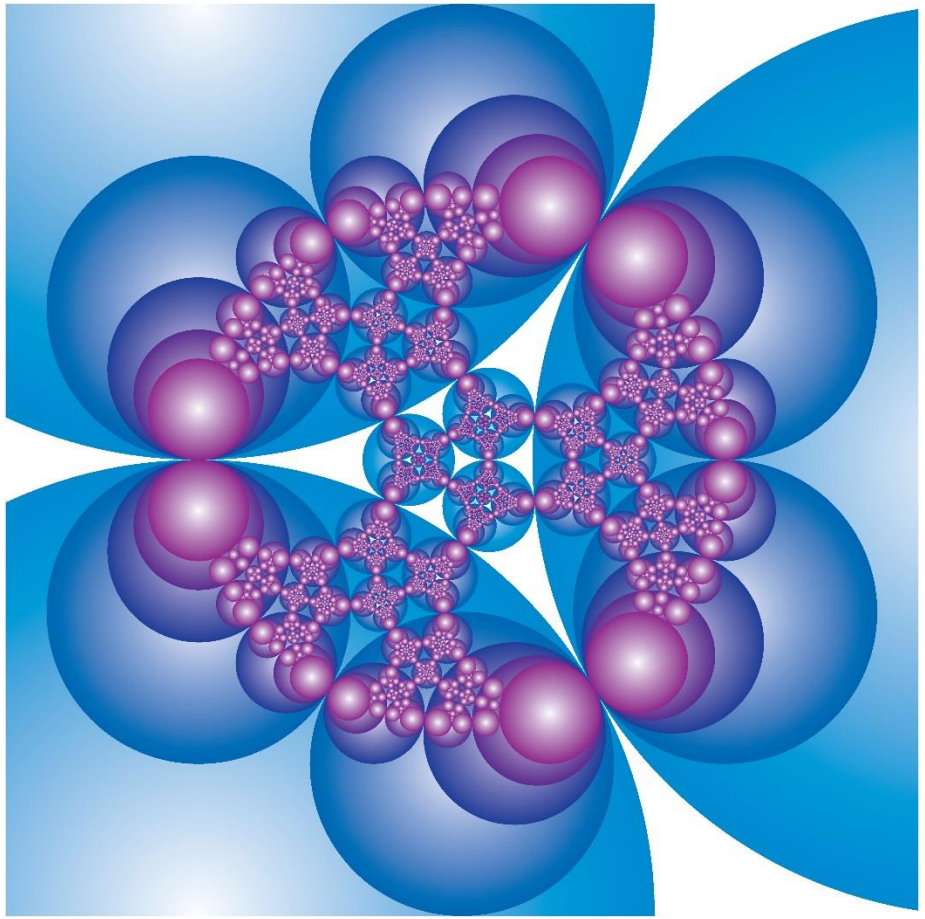
- So mathematics should sit at the very heart of innovation. Making mathematics impactful is not a ‘nice to have’ – it is absolutely vital to achieving our core values as a society.

Some Key Challenges

- UK Research needs better alignment to industrial needs.

- **We need partnerships to make UK efforts achieve critical mass.**
- **We need adequate funding to drive innovation from mathematics into the economy.**
- **We need effective structures to make this happen.**
- **We need to have the right career incentives and career structures in place.**

Review of Knowledge Exchange in the Mathematical Sciences



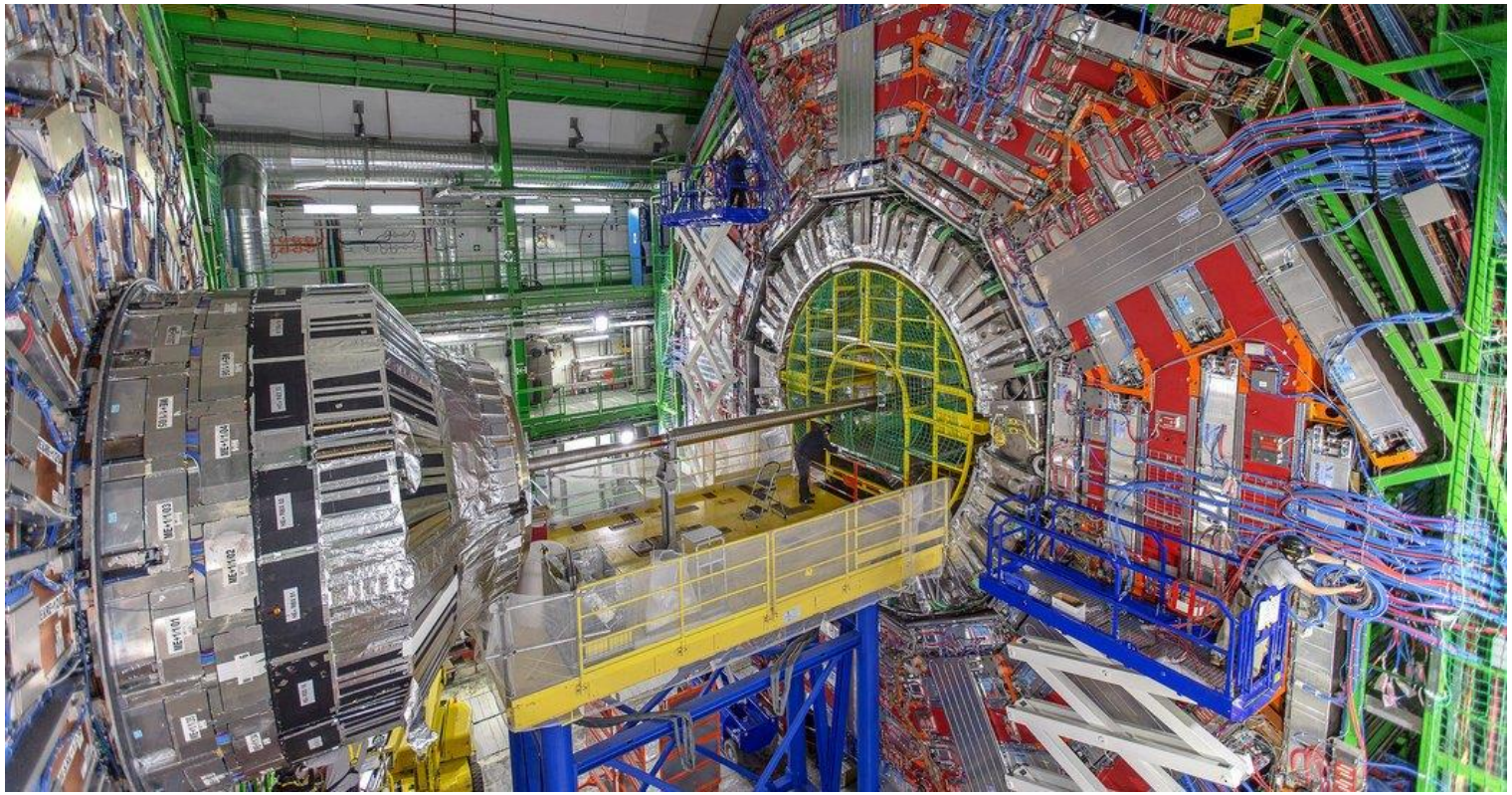
Review of Knowledge Exchange in the Mathematical Sciences

- The review will be officially launched on April 26th at the House of Lords.

- Two of the key challenges that we address in the review : The need for new infrastructure, and the need for new incentives.

Infrastructure

- Here is infrastructure to a physicist …

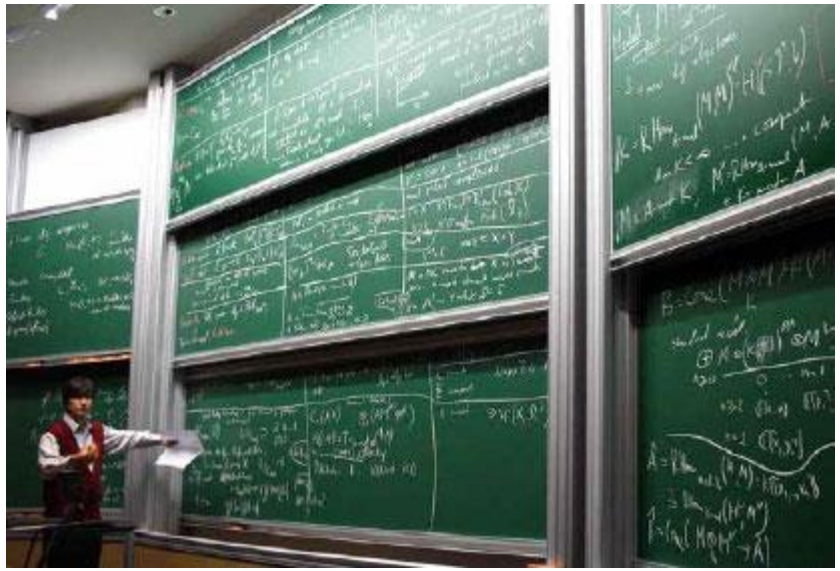


Infrastructure

- Here is infrastructure for a biologist

What does ‘mathematics infrastructure’ look like ?

- Here is what people often think of as infrastructure for mathematics



- This is NOT the key infrastructure of mathematics !

What is infrastructure for mathematics ?

- Infrastructure for mathematics takes many forms – the majority are intended to do three things usefully
- (1) Enable people to network.
- (2) Have a place that people can physically meet in addition to ‘virtual’ institutes.
- (3) Create an environment conducive to research.

How well do we do these things ?

- Networking – do we tend toward ‘silos’ ?
- How about high level networking with industry ? With the service sector ? With government ?
- How about cross-disciplinary engagement ?
- How well are we doing as a community in engaging with the Industrial Strategy challenge fund or Global Challenges fund ?

The structure of funding

- Example : EPSRC are supposed to fund roughly TRL 1 through 3.
- What mechanisms exist to drive things into industry or government and ensure real impact is achieved?
- How easy is it for mathematicians to engage with challenge funds or to know what problems they might work on ?

Recommendations

- To counter the underfunding of the MS research pipeline and adequately underpin MS in the UK, UK Research and Innovation (UKRI) should look to at least triple the funding going to MS across multiple Research Councils, including but not limited to EPSRC and Innovate UK.

Recommendations

- A national centre in impactful mathematics for the UK should be created to work with industry and government to drive mathematical research through to commercialisation. This could be based on existing models, such as the Fraunhofer Institute for Industrial Mathematics in Kaiserlautern or the UK Catapult network, suitably modified to provide national-level integration of low-TRL research from universities and to act as a national KE hub.

Recommendations

- There should be at least one national centre, based on the Heilbronn Institute model, to better enable mathematicians focused on fundamental research to engage directly with government and/or industry.

Recommendations

- An academy for the Mathematical Sciences should be established in order to facilitate links between academia, government and industry. The Academy should act as a focal point and coordinating centre for the community and draw on the deep expertise of the existing learned societies.

Recommendations

- Resources for workshops with industry should be broadened and increased. In particular the Mathematics Study Groups with Industry should be expanded in scope.

Incentives

If people are to work on impactful mathematics then

People need access to ‘problems to work on’.

People need more time to think and less distractions.

People need to have a better career if they make that choice.

We need more PhDs.

Strong incentives should be put in place for cross-disciplinary work between the mathematical sciences and other disciplines.

Recommendations

- Incentives should be created to enable two-way movement of researchers between academia, industry and government.

- KE activities should be fully integrated into MS academic careers and career progression. This should include consideration of KE in academic appointment and promotion criteria, as well as mechanisms to incentivize and support KE activities. Mechanisms should include KE accolades and buy-out of teaching time for academics who complete an industry placement to ensure that academic research productivity is maintained.