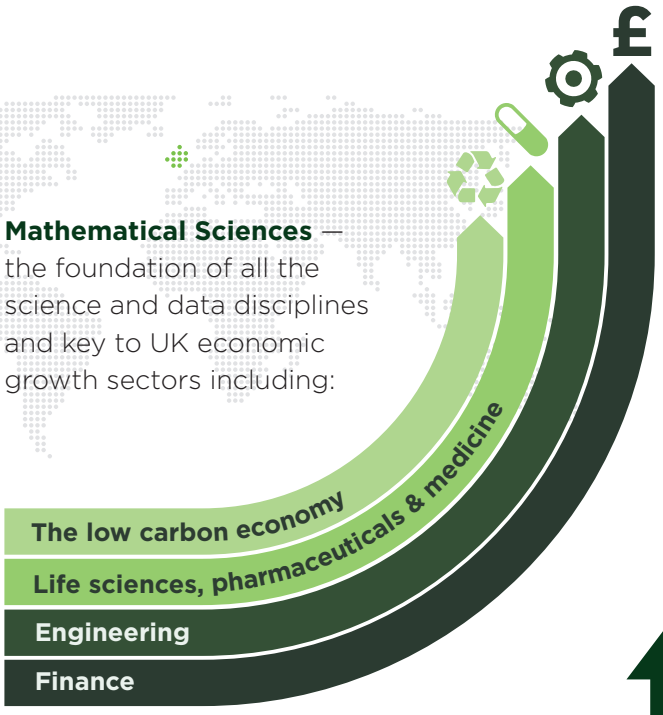
MATHEMATICAL SCIENCES

DRIVING THE UK ECONOMY

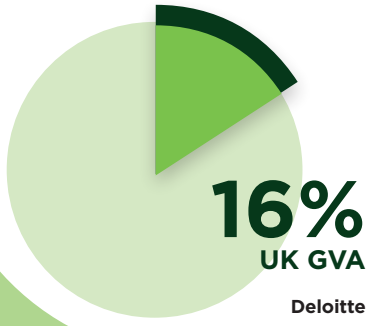
A report by The Council for the Mathematical Sciences

IMPACT

Mathematical Sciences — the foundation of all the science and data disciplines and key to UK economic growth sectors including:



Mathematical Sciences — crucial to the UK economy, currently contributing 16% of UK GVA (£208bn) and 10% of jobs.



Research shows widespread gaps in mathematical knowledge and skills across many sectors and levels of industry and employment. The potential for such weaknesses to fundamentally undermine the UK's economy is evident, and it is in the UK education system where these problems begin.

CHALLENGE

Insufficient Mathematical Sciences graduates, postgraduates and researchers to meet current or future needs of industry and academia.

Employers report difficulty in recruiting skilled Mathematical Scientists across all disciplines. All sectors are clear that there is a need to boost the UK's investment in the Mathematical Sciences.

Nearly three in five people in 'higher managerial and professional occupations' in the UK do not have mathematical skills at even GCSE A*–C level.

ACTION

Need for substantial increase in Mathematical Sciences MSc and PhD numbers, at least doubling in the short term.

University courses across the disciplines are becoming more mathematical in nature, and need to clearly articulate their requirements for mathematical skills.

School mathematics needs to equip more young people to know more mathematics beyond GCSE, and to be confident, robust and fluent in its use.

The UK must develop its intellectual resource and ensure higher level Mathematical Sciences skills across the country to capitalise on potential growth and be a leading force in the global economy.

MATHEMATICAL SCIENCES — **DRIVING THE UK ECONOMY**

Science and mathematics are at the heart of modern life and provide the foundations for economic prosperity

Royal Society

There is an overriding imperative to generate a sufficient number of trained Mathematical Scientists to meet the demands of academia, commerce, education, industry, and research, as well as the many other interfacing academic disciplines for which the Mathematical Sciences provide an essential underpinning. Thirty reports published over the past 5 years (see Annex) by a large number of senior bodies, such as the British Academy and BIS, clearly demonstrate this need. These organisations represent a wide variety of sectors ranging from medicine and biological sciences, to the social sciences and humanities.

For every £1 invested in the sciences in the UK, £9.6 is generated in return[29]. This nearly tenfold return on investment demonstrates quite clearly the vital importance of the sciences to the UK economy. Research in the physical and Mathematical Sciences (engineering, physics, chemistry and mathematics) generates £815bn in UK GVA[29]. Of this massive economic contribution, the Mathematical Sciences itself directly generates £208bn, equating to 16% of the overall GVA of the entire UK. 10% of UK jobs (2.8m jobs) come directly from the Mathematical Sciences sector.[7]

ROI

Every *£1 invested in Science = £9.60 return on investment*

EPSRC

WHY THE UK NEEDS QUALIFIED MATHEMATICAL SCIENTISTS

A recent report from the Council for the Mathematical Sciences (CMS) analysed the importance of mathematical qualifications across a defined base of employment sectors and found that for 2 million employees, a Mathematical Sciences qualification was essential, and for an additional 3 million employees a Mathematical Sciences qualification was desirable[26].

...for 2 million employees a Mathematical Sciences qualification was essential, and for an additional 3 million employees a Mathematical Sciences qualification was desirable.

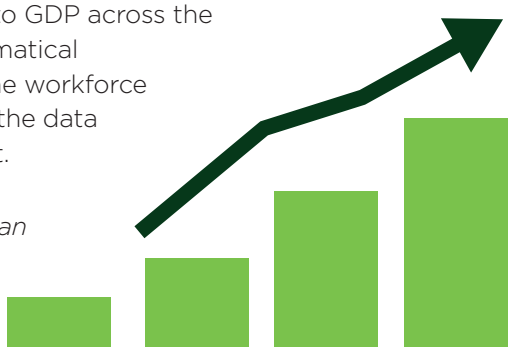
CMS, *The Mathematical Sciences People Pipeline*

As evidenced in the Deloitte report the Mathematical Sciences underpin not only all of the sciences but also a wide range of the humanities and social science based disciplines. The direct contribution of the Mathematical Sciences to UK GVA and to the UK workforce is of huge importance. However, the indirect contribution of the Mathematical Sciences to these wider disciplines — and thus the indirect contribution to the GVA input and workforce numbers of the UK as a whole — is of an even greater magnitude[9].

The current central economic role of the Mathematical Sciences is set to increase. The Science Council predicts that advanced manufacturing, life sciences and pharmaceuticals, the low carbon economy, professional and financial services, the digital economy, engineering and construction will continue to be growth sectors over the coming decades[6]. The Mathematical Sciences significantly inform, and in many cases are crucial to, every one of these sectors.

Moreover, Big and Open Data are exciting new sectors that the British Academy predicts will contribute an additional £147bn per annum to GDP across the economies of the European Union by 2020[23]. The Mathematical Sciences will be of central importance to ensuring that the workforce has the required skills for the UK to be a leading force in the data revolution and to maximise its potential economic output.

£147bn



Big and Open Data will contribute an additional £147bn to GDP by 2020

British Academy, *Count Us In: Quantitative skills for a new generation*

THE UK MATHEMATICAL SCIENCES PEOPLE PIPELINE

By 2030, over 7 million people will be employed in either a primary or secondary science role...

Science Council

As so many skills sectors continue to grow and expand, the mathematically trained workforce must grow to meet the demand.

Research from the Science Council has indicated that by 2030, over 7 million people will be employed in either a primary or secondary science role[6], an increase of over 900,000 workers from 2009. Factoring in new sectors such as Big Data may further increase the numbers required. With Mathematical Sciences being at the foundation of all of the science and data disciplines the strain on the Mathematical Sciences people pipeline will inevitably increase. This raises a fundamental question: how is the UK equipped to cope with this strain and how is it placed to supply the people and skills necessary to maintain this vast and vital economic contribution and to develop the UK's position at the forefront of scientific innovation?

...in other words these 7 million people will require mathematical science skills

Mathematical Sciences graduates are in high demand. The recent CMS report on the Mathematical Sciences People Pipeline has identified that 88% of doctoral graduates in the Mathematical Sciences are employed 6 months after graduation, and 92% of Mathematical Sciences undergraduates are in work or further study after six months[26]. In addition, salaries for around half of those whose role requires Mathematical Sciences as *'essential'* are £29k or above compared with only 19% of the UK workforce as a whole[26]. Mathematics is rightly seen as a challenging degree by employers and valued for its transferable skills: indeed postgraduate Mathematical Scientists have the highest average starting salary among all UK holders of postgraduate degrees[1].

Mathematical Sciences graduates receive one of the highest starting salaries compared with other disciplines

BIS, *One Step Beyond*

There is a need for a healthy pipeline of individuals who are mathematically skilled and trained at all levels to inform a huge section of industry and employment. Such a pipeline should ensure the vigour of UK industry, support growth, and by building a skilled and talented UK workforce will ultimately lead to the attraction of further global investment into the UK[1].

But this pipeline is at risk. After some years of steady increase, the overall number of Mathematical Sciences graduates fell between 2012-13 and 2013-14, and this decrease was particularly marked for postgraduate qualifications[30].

Mathematics, statistics and computational biology skills are lacking particularly at postgraduate and postdoctoral levels, with many respondents reporting difficulties in recruiting adequately skilled researchers at these levels.

BBSRC and MRC

Nesta also reports problems in the recruitment of data analysts, with two thirds of data-active companies struggling to fill at least one data analyst vacancy, potentially catastrophic for this emerging industry[27]. At a more general level as many as three in five of those in higher managerial and professional occupations do not have mathematical skills at GCSE A*-C level and are unequipped to meet the mathematical or statistical demands of their roles[28].

MATHEMATICAL SCIENCES EDUCATION — SCHOOL AND COLLEGE LEVEL

The Advisory Committee on Mathematics Education (ACME) reported that the UK needs more young people to know more mathematics and to be confident, robust and fluent in their use of it[4]. They stated that many more university courses in many disciplines were becoming increasingly quantitative and in addition there is also a steady shift in employment away from manual and low skill jobs towards those requiring higher levels of management expertise and problem-solving skills, many of which are mathematical in nature. ACME estimated that of those entering higher education in any year, some 330,000 would benefit from recent experience of studying mathematics (including statistics) at a level beyond GCSE but fewer than 125,000 will have done so.

200,000 students each year enter higher education without the required mathematical science skills.

ACME, *Mathematical Needs*

Universities should make clear the level and extent of mathematics encountered within each of their degree programmes.

The ACME report stated that 'At present, many universities do not indicate the mathematics to be encountered within their degree programmes in a variety of subjects. As a result, many 16-year-olds decide not to continue mathematics post-GCSE, not realizing that it would be much to their advantage to do so; similarly those who do take mathematics (e.g. at A-level) are often unaware of the options that would best suit them'[4]. In the same report, employers emphasized the importance of people having studied mathematics to a higher level than they will actually use, which provides them with the confidence and versatility to use mathematics in the many unfamiliar situations that occur at work.

A co-ordinated and continuous effort at improving quantitative skills across all phases of education and employment, in all four nations of the UK is... urgently needed. The Government should set out a strategy for realising this vision

British Academy, *Count Us In: Quantitative skills for a new generation*

MATHEMATICAL SCIENCES EDUCATION — HIGHER LEVEL QUALIFICATIONS

To drive the economy forward there is a need for a mathematically trained skillset across the widest economic spectrum. Not enough Mathematical Sciences graduates choose to continue into postgraduate training to meet the demands of industry and to deliver ground-breaking fundamental research continually developed within the Mathematical Sciences discipline itself. In its 2010 report the Department for Business, Innovation and Skills (BIS) stated that making postgraduate provision more responsive to employer needs and encouraging more people to train to postgraduate level will ensure that the UK has the higher level skills needed to succeed in a global economy[1]. There is a need for an increased number of higher degree level graduates in the Mathematical Sciences to populate the future academic research base as well as to encourage increased cooperation between industry and academia.

Inadequate numbers of PhD level graduates are being produced to meet industry demand, with insufficient financial support for students

EPSRC, *Mathematical Sciences People Pipeline Project*

Mathematics, Statistics and Computation are vulnerable capabilities and skills within the UK bioscience and biomedical research base particularly at postgraduate, postdoctoral and early career researcher levels.

BBSRC and MRC, *Vulnerable Skills and Capabilities*

Inadequate numbers of PhD level graduates are being produced to meet industry demand, with insufficient financial support for students[2]. The lack of financial provision for UK Masters courses has been noted by the EPSRC, while the Masters degree model itself was highlighted as particularly beneficial in providing a strong foundation for postgraduate research[18]. Without this, UK students are disadvantaged when competing for jobs against graduates from other EU countries and overseas, where longer routes to PhDs provide more experience, which is viewed more favourably by employers.

INTERNATIONAL CHALLENGES

The need for more qualified mathematicians is not restricted to the UK. A report about the Mathematical Sciences in 2025, published by the American National Academy of Sciences, stated 'Mathematical Sciences work is becoming an increasingly integral and essential component of a growing array of areas of investigation in biology, medicine, social sciences, business, advanced design, climate, finance, advanced materials, and many more. All of these activities are crucial to economic growth, national competitiveness, and national security, and this fact should inform both the nature and scale of funding for the Mathematical Sciences as a whole'[8].

80%+

Over 80% of UK Mathematical Sciences research outputs recognised as excellent or internationally world-leading in REF2014.

It is within this global context that the UK must develop its intellectual resource. If the UK is to capitalise on potential economic growth it is imperative that more people with graduate and postgraduate level qualifications in the Mathematical Sciences are encouraged and developed from the current and future student base within the UK, with an appropriate associated level of support.

The most recent International Review of Mathematical Sciences (IRMS) commissioned by the Engineering and Physical Research Council, carried out in 2010, found that overall, Mathematical Sciences research in the UK is excellent on an international scale[3]. More recently the 2014 Research Excellence Framework found that over 80% of UK Mathematical Sciences research outputs were recognised as excellent and internationally world leading.

> The UK must not only maintain but further develop the Mathematical Sciences people pipeline to remain competitive globally within the research arena, attract global businesses to locate high-value operations to the UK, and meet the demands of academia, industry and commerce in producing a sufficient number of skilled mathematicians graduating year on year at the required level.
>
> ***International Review of Mathematical Sciences***

ABOUT THE COUNCIL FOR THE MATHEMATICAL SCIENCES (CMS)

The Council for the Mathematical Sciences (CMS) was established in 2001 by the Institute of Mathematics and its Applications (IMA), the London Mathematical Society (LMS) and the Royal Statistical Society (RSS). In 2008 the Edinburgh Mathematical Society (EMS) and the Operational Research Society (ORS) also became members of the CMS. The CMS comprises representatives and observers from the Mathematical Sciences community, including the Presidents and Chief Executives of these societies.

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 objectives of the Council for the Mathematical Sciences are:

- to provide an expert advisory group on matters affecting the Mathematical Sciences in higher education and research in the UK.
- to engage (proactively and responsively) with government and other decision-makers and to respond coherently and effectively to proposals in which the Mathematical Sciences in higher education and research in the UK have a role, or may be affected.
- to engage with funding agencies for higher education and research on maintaining and improving a strong mathematics base in the UK.
- to bring together the Mathematical Sciences community and facilitate communication between the community and other stakeholders to explore common issues and potential solutions.

REPORTS REFERENCED

Ref.	Date published	Produced by	Title
1	2010	Department for Business, Innovation and Skills (BIS)	Smith Report: One Step Beyond: Making the most of postgraduate education
2	2010	LMS	Response to International Review of Mathematical Sciences
3	2010	IRMS	International Review of Mathematical Sciences
4	2011	ACME	Mathematical Needs
5	2011	CMS	House of Lords Science and Technology Sub-Committee Call for Evidence: Higher Education in STEM Subjects
6	2011	Science Council	The current and future UK science workforce
7	2012	CMS	Mathematical Sciences research: Leading the way to UK economic growth
8	2012	National Academy of Sciences	Fuelling Innovation and Discovery: The Mathematical Sciences in the 21st Century
9	2012	Deloitte	Measuring the Economic Benefits of Mathematical Science Research in the UK
10	2013	National Academy of Sciences	The Mathematical Sciences in 2025
11	2013	The Sutton Trust	The Employment Equation: why our young people need more maths for today's jobs
12	2013	LMS	Advancing Women in Mathematics: Good practice in UK University Departments
13	2013	CMS	Briefing for Roundtable with David Willetts
14	2014	LMS	Academic Mathematical Sciences Staff in UK Higher Education Institutions
15	2014	LMS	Research Income of Mathematical Sciences in UK Higher Education Institutions
16	2014	HEA	Mathematical transitions: a report on the mathematical and statistical needs of students undertaking undergraduate studies in various disciplines
17	2014	HESA	Destination of Leavers from Higher Education Institutions data
18	2014	EPSRC	Mathematical Sciences People Pipeline Project
19	2014	Institute of Physics	Mathematical physics: What is it and why do we need it?
20	2014	LMS	The Future UK Mathematical Landscape (President's Presentation to HoDoMs)
21	2014	Royal Society	Vision for science and mathematics education
22	2015	BBSRC and MRC (Biotechnology and Biological Sciences Research Council and Medical Research Council)	Vulnerable Skills and Capabilities
23	2015	British Academy	Count Us In: Quantitative skills for a new generation
24	2015	Reidun Twarock	Funding for Mathematics in the Wellcome Trust Portfolio
25	2015	Academy of Social Sciences	Making the Case for the Social Sciences (No. 10 Wales)
26	2015	CMS	The Mathematical Sciences People Pipeline
27	2015	Nesta	Skills of the Datavores: Talent and the data revolution
28	2015	Nesta	Analytic Britain: Securing the right skills for the data-driven economy
29	2015	Philip Nelson	EPSRC presentation
30	2015	HESA	Higher Education Statistics for the United Kingdom 2013/14

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