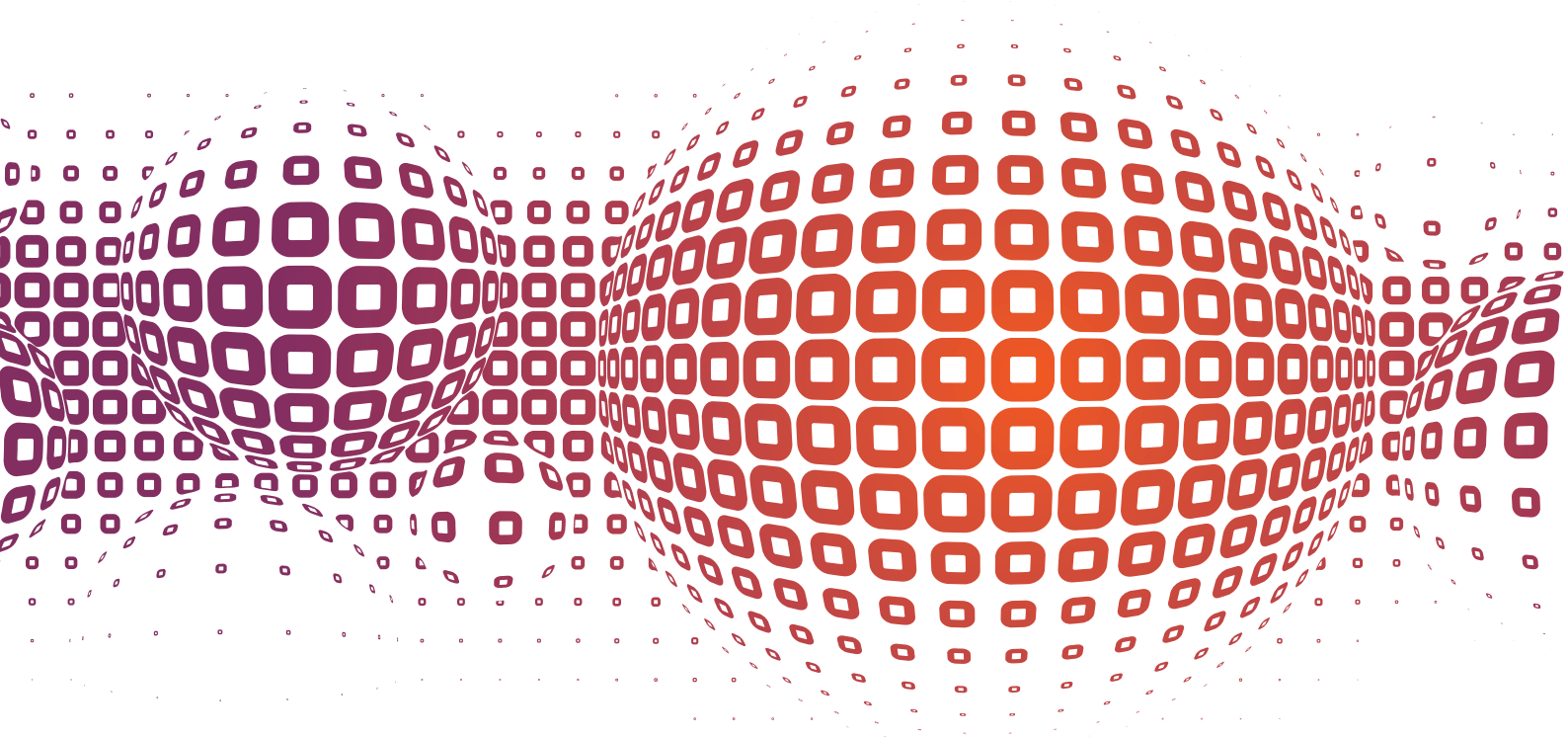
EPSRC
Investing in research for discovery and innovation

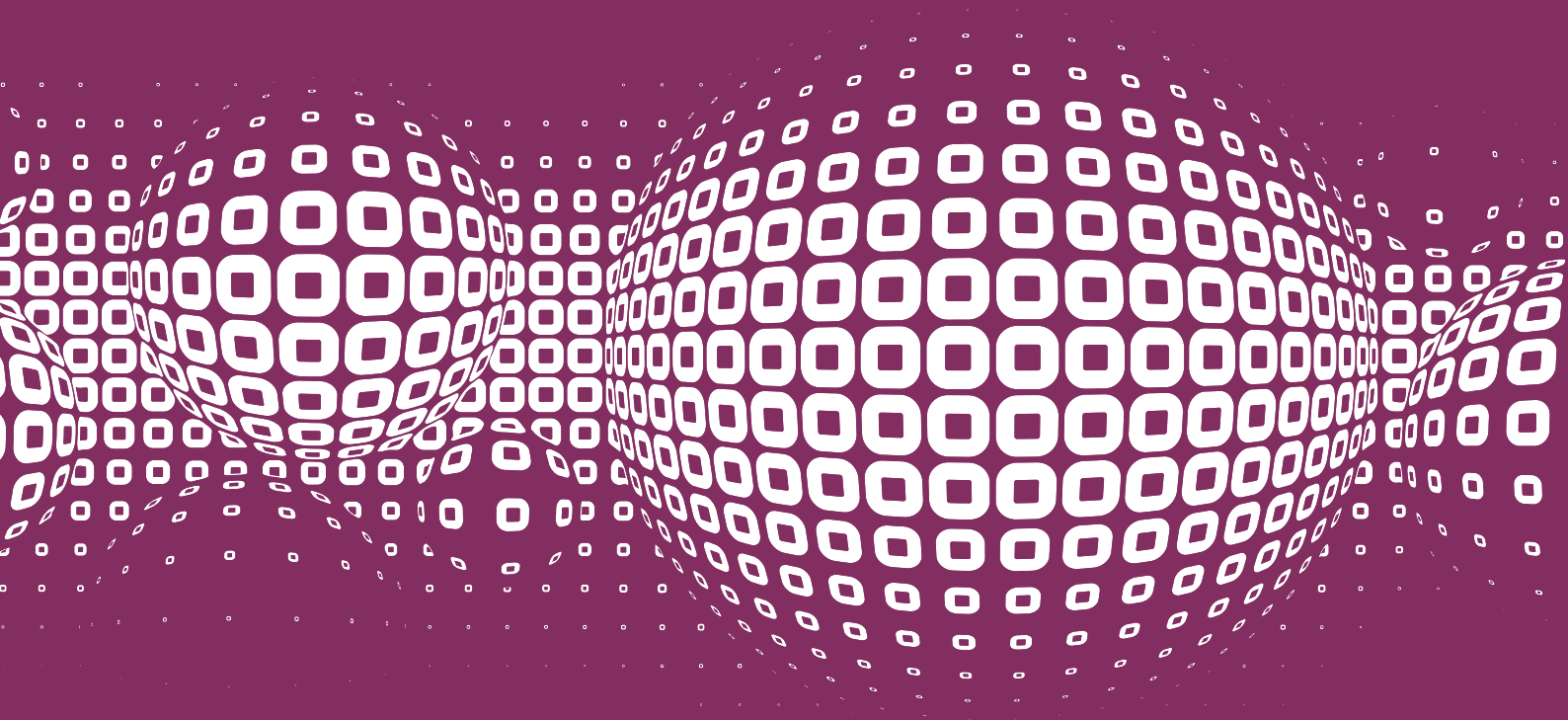
# Investing in excellence, delivering impact for the UK

## Insights from the Research Excellence Framework 2014



Engineering and Physical Sciences
Research Council

# How UK success depends on engineering and physical sciences research



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# Foreword

## The impact of research

The results of the most recent national assessment of university research in the UK, the Research Excellence Framework (REF), were published in December 2014; they provide a comprehensive assessment of research performance and of the wider impact of research on society, including nearly seven thousand impact case studies.

For EPSRC, this offered us a unique opportunity to explore and understand how our investments over the last two decades have delivered benefits across many areas of the UK economy and society. I would like to extend thanks to the Higher Education Funding Council for England (HEFCE) for granting us early access to the impact case studies, and to EPSRC staff who were involved in systematically capturing and analysing a vast amount of information from the 1226 impact case studies which were directly relevant to our remit.

In fact, over 85% of the impact case studies in engineering and physical sciences involved research and/or researchers who were funded by EPSRC, demonstrating the critical role of the council in supporting excellent research that delivers impact. The impact case studies cite over £1 billion of EPSRC funding coupled with a similar level of funding from other sources including government, EU and industry and provide strong evidence of the high levels of additional investment that EPSRC support can attract.

EPSRC's role in stimulating growth extends even further. Research funded by the council can be associated with approximately £80 billion of economic activity, including £16 billion of cost savings to the public and private sector. Particularly notable is the fact that EPSRC investments have led to the creation of more than 400 new businesses, employing an estimated 50,000 staff and contributing some £4 billion to the economy.

But it takes time to deliver impact: our analysis reinforced the importance of long-term, sustained funding for excellent research and that although benefits may be realised within a short timeframe, in general it takes much longer for impacts, social, economic and cultural, to be realised.

EPSRC investment is vital in ensuring the future of the UK as a productive, connected, resilient and healthy nation – one that is always at the forefront of innovation. To achieve this we will continue to work in partnership across all sectors to nurture scientific development and ensure the UK is the best place to research, discover, and innovate. No doubt there will be many more success stories to be told in future REF impact case studies.

Philip Nelson
Chief Executive
EPSRC

# Executive summary

## Engineering and physical sciences delivers benefits across UK economy and society

A key feature of the Research Excellence Framework (REF) 2014 is the introduction of 'impact' as one of the three elements for assessment. The impact case studies submitted as part of the assessment provide a rich source of information. The Engineering and Physical Sciences Research Council (EPSRC) has undertaken a detailed and systematic analysis of 1226 of the case studies submitted in the engineering and physical sciences areas, the results of which illustrate the magnitude and scale of impacts arising from this research.

## Main findings

- 86% of the REF impact case studies in the Engineering and Physical Sciences (EPS) Units of Assessment (UoA) involve EPSRC supported research or researchers. As EPSRC supports approximately one third of EPS REF-eligible researchers at any given time (and two thirds during the REF assessment period) this highlights the extent to which EPSRC-supported researchers are delivering impact.

- The impact case studies cite ~£1.1 billion of investment by EPSRC combined with an additional ~£1 billion research funding from other sources including government, EU and industry. This highlights the significant role of EPSRC as an investor. This is also borne out by the figures derived from the REF that show that research council funds are the largest single source of external income to university departments in EPS subjects (44% of the total overall), the majority of which comes from EPSRC.

- In addition to the research funding, evidence is given in the studies of at least £5 billion investment for further development and commercialisation.

- Roughly two thirds of the EPSRC funding cited is through 'standard research grants' of which ~70% were investigator-led. There is also a significant proportion of 'critical mass' support cited, for example Science and Innovation Awards and Interdisciplinary Research Collaborations

- The majority (i.e. ~90%) of the 171 impact case studies which refer specifically to support from Innovate UK (and predecessor organisations) also cite EPSRC funded research/ researchers.

- In addition to a broad range of policy, environmental and societal impacts (in areas such as healthcare, energy and transport) the quantified impacts cited include:

    - £16.2 billion cost savings (of which £5.9 billion are in the public sector and £10.3 billion in the private sector).
    - 394 new businesses (spin-out companies) created of which 87% are active; collectively these represent ~47,000 jobs and a contribution of ~£4 billion to the economy.
    - Revenue from additional sales and other economic activity worth £61.1 billion.

# 1

# Introduction

A key feature of the Research Excellence Framework (REF) 2014 is the introduction of 'impact' as one of the three elements for assessment (together with 'outputs' and 'environment'). There has been considerable interest in the development of a suitable methodology for the assessment of impact. An extensive pilot exercise was undertaken, as a result of which it was agreed that assessment should be primarily based on expert review of impact case studies and that in view of the variety of subjects and impact types, the format for these should be non-prescriptive. Universities invested significant levels of effort in the selection and preparation of impact case studies and impact templates (at an estimated[1] median cost of £7,500 for impact case studies and £4,500 for impact templates). EPSRC has undertaken an extensive analysis of the impact case studies in the Engineering and Physical Sciences (EPS) Units of Assessment (UoA) (1226 of which were relevant to the EPSRC remit).

The exercise was undertaken in full recognition of the fact that the impact case studies cannot be assumed to represent the entirety of impact-related activity in view of a number of factors, including the constraints of the REF requirements and the lack of a systematic framework for recording quantitative data, such as funding sources. Nevertheless, they provide a rich source of information, which illustrates the magnitude and scale of impacts arising from EPS research in a way that has not previously been possible.

*1 Preparing impact submissions for REF 2014: An evaluation – RAND Europe 2015, http://www.hefce.ac.uk/pubs/rereports/Year/2015/REFimpacteval/Title,103726,en.html*

# 2 Methodology

As the impact case studies consist primarily of unstructured text, an initial manual data-capture step was required: EPSRC staff read each of the impact case studies and entered key quantitative and qualitative information in a structured database. The information captured was based on an analytical framework which reflected the set of key questions that this analysis was intended to address (Annex 1). A template was developed and tested, which enabled staff to record information on a number of aspects of the impact case studies using a structured approach to ensure consistency in the data. These aspects included: researchers involved, subject areas of the research, funding, collaboration, public and private sector relevance, quantified impacts such as cost savings and sales, types of impacts including creation of new businesses, environmental, societal and policy impacts.

Impact case studies were allocated using a combination of UoA and keyword-based classification so that staff were working with impact case studies within their area of responsibility and therefore were familiar with the subject (as well as benefitting from the opportunity to understand more of the impacts arising within their area). Initial training/ induction sessions were held for all staff involved, and dipstick checking of ten per cent of the completed templates helped to ensure consistency and accuracy of the data captured. All of our analyses of impacts are based on the information that was presented in the case studies; figures have only been captured where provided and are therefore conservative as in many cases the impacts have not been quantified.

# Significance of EPSRC support in REF impact case studies

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A total of 1492 impact case studies were submitted to UoA 8 – 15, 1282 of which were provided to EPSRC for analysis and, of those, 1226 are within the EPSRC's remit (i.e. excluding the areas of physics such as particle physics which are not funded by EPSRC). Of the 1226 within EPSRC's remit, 640 (52%) explicitly cite EPSRC funding and an additional 411 (i.e. 34%) include researchers funded by EPSRC over the REF period (1993-2008). Overall, 1051, (i.e. 86%) of the impact case studies involve EPSRC supported research/researchers.

Figure 1 shows the numbers of impact case studies submitted by universities to the UoA relevant to EPS and the numbers made available to EPSRC (i.e. excluding the confidential case studies).

| UoA | Impact case studies submitted[2] | Impact case studies provided to EPSRC (no. within EPSRC remit shown in brackets) | Impact case studies citing EPSRC as a funder | Impact case studies involving EPSRC-supported researchers (but EPSRC not cited as funder) | % of impact case studies with links to EPSRC funded research or researchers |
|---|---|---|---|---|---|
| 8 Chemistry | 152 | 119 (111) | 45 | 56 | 91% |
| 9 Physics | 203 | 179 (135) | 78 | 41 | 88% |
| 10 Mathematical Sciences | 236 | 207 (206) | 81 | 81 | 79% |
| 11 Computer Science and Informatics | 280 | 247 (247) | 131 | 76 | 84% |
| 12 Aero, Mech, Chem and Manufacturing Engineering | 138 | 120 (120) | 67 | 41 | 90% |
| 13 Electrical and Electronic Engineering, Metallurgy and Materials | 141 | 122 (122) | 71 | 37 | 89% |
| 14 Civil and Construction Engineering | 51 | 50 (50) | 32 | 11 | 86% |
| 15 General Engineering | 291 | 238 (235) | 135 | 68 | 86% |
| Total | 1492 | 1282 (1226) | 640 | 411 | 86% |

**Figure 1. Number and percentage of impact case studies with links to EPSRC supported research/ researchers**

It is interesting to compare these data with the overall level and distribution of EPSRC funding of the research base. To gain a better understanding of this an analysis was undertaken of EPSRC support in terms of institutions, researchers and investment. Figure 2 shows that out of the HEIs eligible to submit to the REF in EPS subjects, 50-70% are in receipt of EPSRC grants.

*2 Numbers from Figure 1 in HEFCE Main Panel B Overview Report, http://www.ref.ac.uk/media/ref/content/expanel/member/Main%20Panel%20B%20overview%20report.pdf*

# 3 Significance of EPSRC support in REF impact case studies

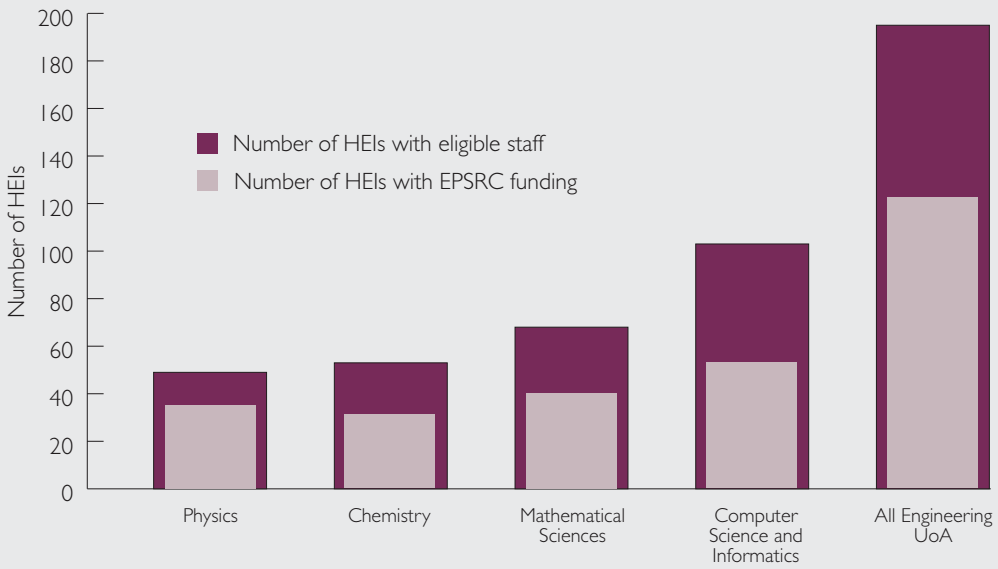


**Figure 2. Number of institutions with REF eligible staff receiving funding from EPSRC**

Figures 3 and 4 show the numbers of researchers receiving support from EPSRC compared with the numbers of researchers eligible for submission to the REF in the EPS UoA and those who were included in submissions.

These data show that there were 16,500 researchers eligible to submit to REF (UoA 8-15); EPSRC supports ~6000 at a given time and over the REF assessment period (2008-2013) supported nearly 11,000 individuals. So EPSRC supported ~36% of eligible researchers on the census date (47% of those submitted) and roughly two thirds of the researcher population over the REF assessment period. This varies by subject – Figure 3 shows that for those researchers that can be classified by discipline, the proportions supported at any one time range from 17% (computer science) to 35% (chemistry).

There are a significant number of researchers who could not be mapped to an EPS discipline on the basis of their department name, the actual proportions of researchers supported by EPSRC is likely to be higher.

| | REF eligible (from HESA contextual data) | REF category A headcount (% EPSRC support over REF assessment period) | In receipt of EPSRC support on 31 October 2013 (% of REF eligible in brackets) | In receipt of EPSRC support during the REF assessment period (% of REF eligible) |
|---|---|---|---|---|
| Chemistry | 1507 | 1267 (83%) | 532 (35%) | 1048 (70%) |
| Physics | 1891 | 1771 (57%) | 601 (32%) | 1015 (54%) |
| Mathematics | 2313 | 2004 (46%) | 504 (22%) | 916 (40%) |
| Computer Science | 3614 | 2157 (59%) | 609 (17%) | 1265 (35%) |
| All Engineering | 7206 | 5265 (69%) | 1994 (28%) | 3636 (50%) |
| Other | | | 1632 | 3035 |
| Total | 16531 | 12464 (88%) | 5872 (36%) | 10915 (66%) |

**Figure 3. Number of REF eligible, REF submitted and EPSRC-supported researchers**

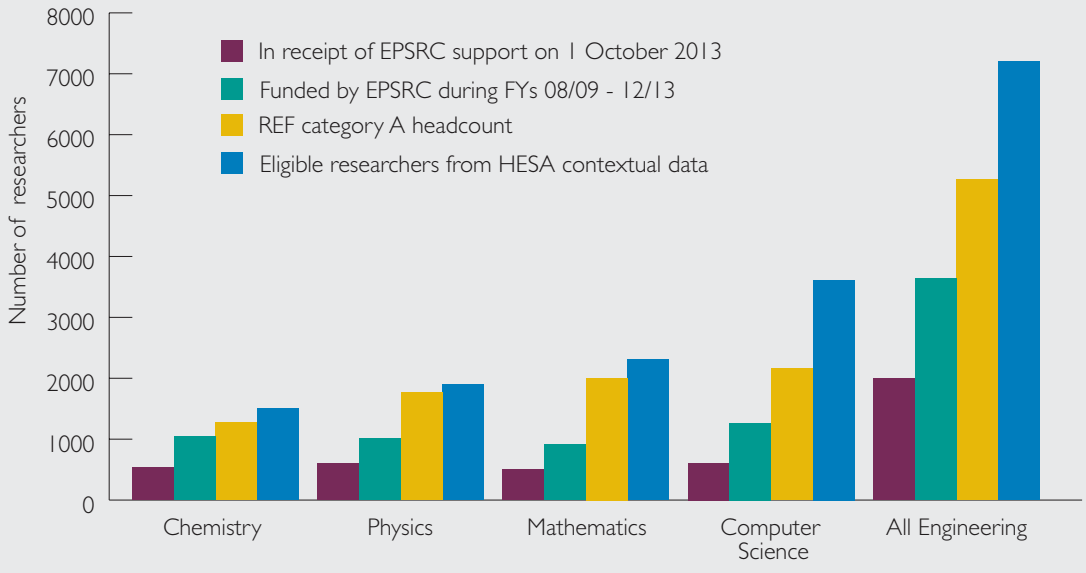


**Figure 4. Snapshot and total numbers of researchers[3]**

*3 EPSRC Management Information System, HEFCE Main Panel B Overview Report and REF contextual data (HESA), http://www.ref.ac.uk/panels/paneloverviewreports/*

# 4 Significance of EPSRC support during REF period

Higher Education Statistics Agency (HESA) contextual data (Figure 5) shows the main sources of income to university departments over the last ten years; this highlights the significance of research council funding for Main Panel B (mostly EPS subjects). This provides a very different picture when compared with Main Panel A (medical and life sciences) where research council funding is only the third most important source (after UK charities and UK government). Also noticeable is the increasing importance of EU funding in EPS areas, particularly over the last few years.

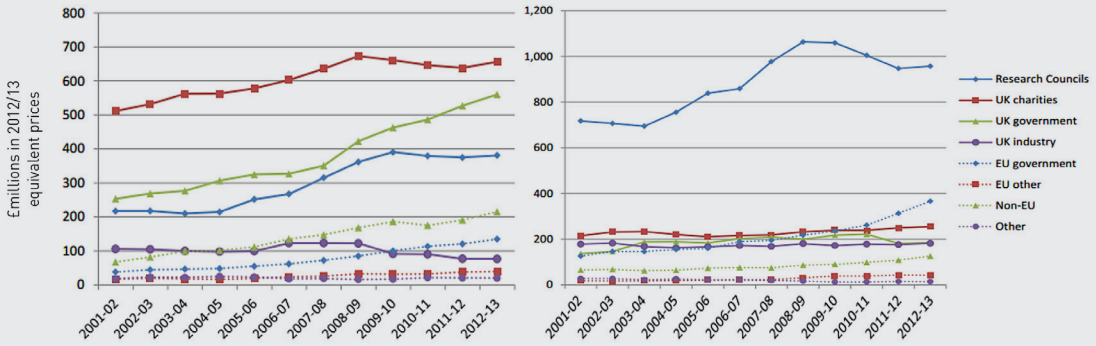


**Figure 5. External income by source to university departments[4]**

Overall the total external research income for the Main Panel B subjects remains fairly constant in real terms during the REF period:

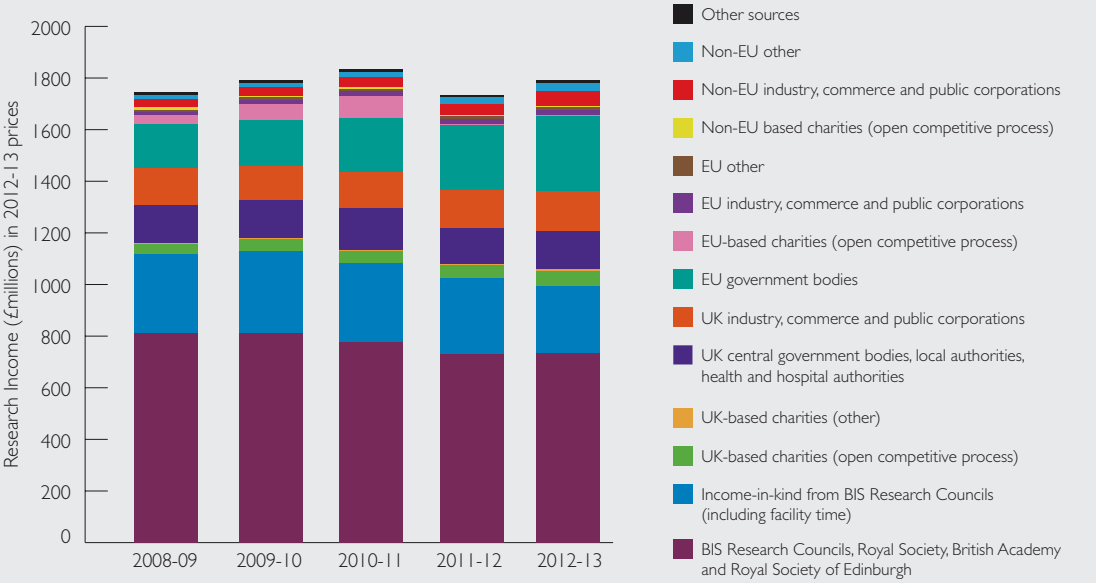


**Figure 6. Total external income by funding source over the REF period[5]**

*4 HEFCE Main Panel A and Main Panel B Overview Reports, http://www.ref.ac.uk/panels/paneloverviewreports/*
*5 HEFCE Main Panel B Overview Report, http://www.ref.ac.uk/panels/paneloverviewreports/*

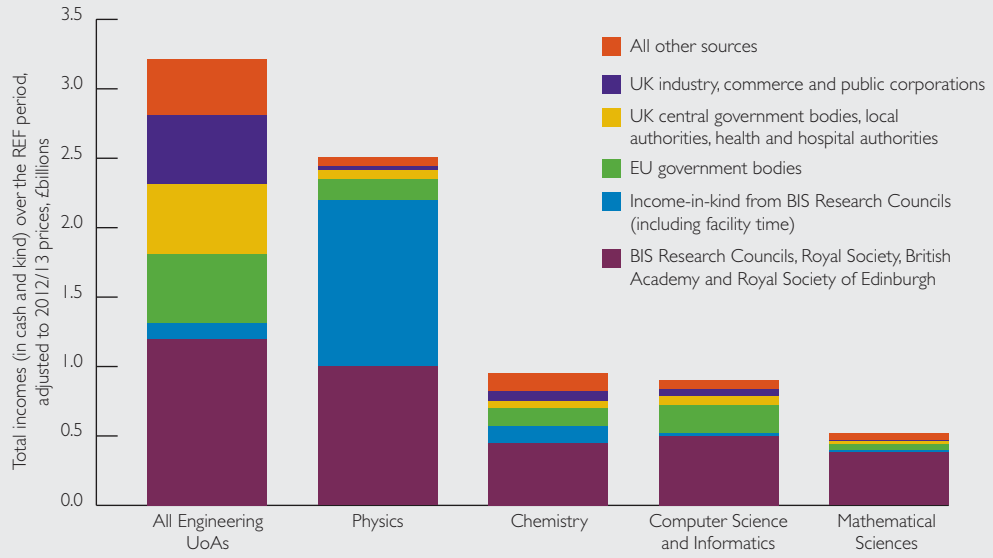


**Figure 7. External income to Main Panel B subjects over the REF assessment period (2008-2013) adjusted to 2012/13 prices[6]**

Further analysis by individual disciplines (Figure 7) shows that research council funding is the most significant source of external income for all of the EPS subjects, accounting for 44% of the total overall (ranging from 40% to 66% of the total external income – see Figure 8). This is especially true for mathematics and physics; although funding for physics also comes from the Science and Technology Facilities Council, the primary source for EPS subjects is EPSRC (total EPSRC investment over the REF assessment period is ~£3 billion). Charts showing trends in external income by source over the REF period for individual UoA are included in Annex 2.

| | All Engineering UoA (£m) | Physics (£m) | Chemistry (£m) | Computer Science and Informatics (£m) | Mathematical Sciences (£m) |
|---|---|---|---|---|---|
| BIS RCs, Royal Society, British Academy and Royal Society of Edinburgh | 1282 (40%) | 1011 (41%) | 547 (52%) | 396 (50%) | 234 (66%) |
| Income-in-kind from BIS RCs | 105 | 1181 | 118 | 2 | 0 |
| EU government bodies | 459 | 146 | 130 | 210 | 37 |
| UK central government bodies, local authorities, health and hospital authorities | 464 | 56 | 55 | 73 | 17 |
| UK industry, commerce and public corporations | 501 | 29 | 65 | 48 | 15 |
| All other sources | 383 | 71 | 134 | 63 | 51 |
| Total | 3194 | 2494 | 1049 | 792 | 354 |

*Note: The figures in brackets are a percentage of the total.*

**Figure 8. External income to EPS subjects over REF assessment period[7]**

*6, 7 HEFCE Main Panel B Overview Report, http://www.ref.ac.uk/panels/paneloverviewreports/*

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# Analysis of EPS REF impact case studies

A mapping of the impact case studies to the sectors for which the impacts were relevant (Figure 9 below) highlights the extent to which EPS produce impacts across every area of the economy and society; with notably high levels in healthcare, aerospace and defence, information technologies and manufacturing.

The impact case studies were also mapped against a number of sectors highlighted by the government as key for UK growth and productivity (Figure 10 below); the importance of EPS to key economic sectors is clearly highlighted.

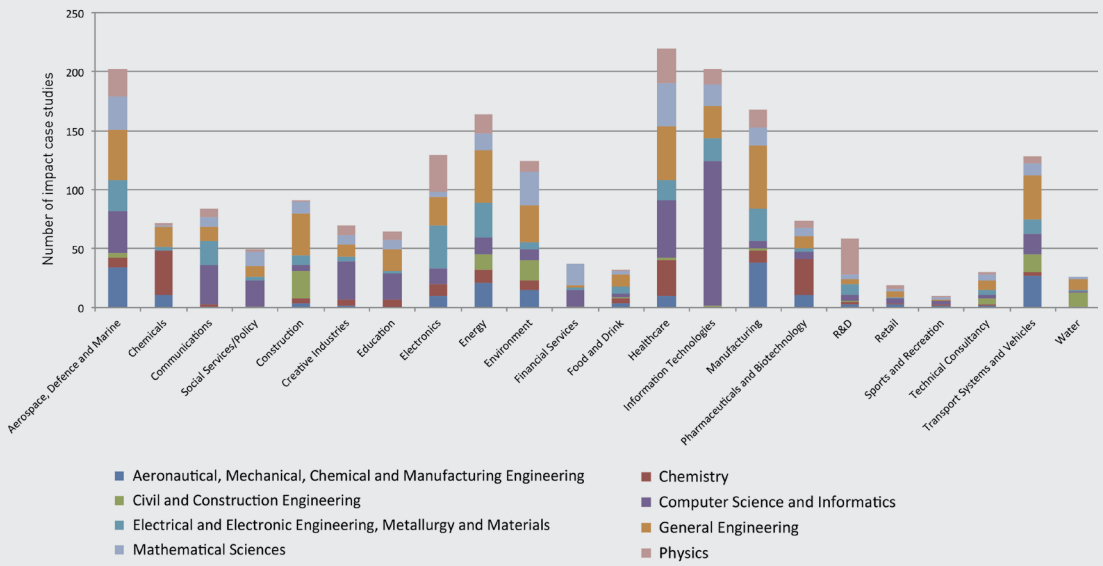


**Figure 9. Impact case studies – relevance by sector and UoA**

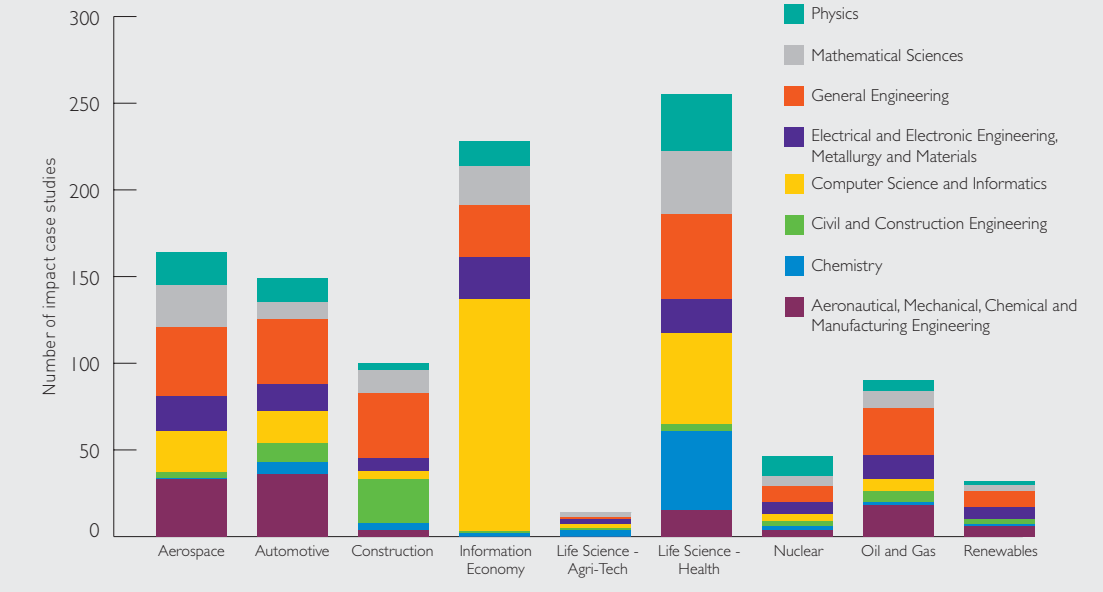


**Figure 10. Impact case studies – relevance to key economic sectors**

# Funding for research underpinning REF impact case studies

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Funding sources were not cited systematically in the REF impact case studies; significant levels of under-reporting are apparent. Nevertheless, a comparison of the amounts cited in the studies, with the data on income to university departments provided as part of the contextual data from the Higher Education Funding Council for England (HEFCE) (Figure 11), shows that in terms of orders of magnitude, the ratios between different funding sources are broadly similar.

As the timeframes for the underpinning research and REF assessment period are different, it was not possible to make a direct comparison of the numbers. The amount of industrial funding cited in the impact case studies appears to be relatively low; this is likely to be due to a combination of under-reporting and the fact that industrial funding tends to be used for next-stage development rather than the underpinning research. At least £5 billion of further investment is listed in the impact case studies, most of which comes from industrial sources.

| Funding Source | Amount cited as directly connected to impact case studies (£m) | Total income to university depts over REF assessment period (£m)** |
|---|---|---|
| EPSRC* | 1110 | 3470 |
| Other RCs | 114 (including ~£9m MRC and ~£13m BBSRC) | |
| Other government sources | 174 | 664 |
| DTI/TSB | 84 | |
| EU (Govt) | 462 | 983 |
| Charity | 35 | 265 |
| Industrial | 149 | 922 |

**Total EPSRC research investment over the period (2008-2013) is £3.5 billion.*
*** Figures for UoA 8-15 taken from Table 13 in the HEFCE Main Panel B Overview Report.*

**Figure 11. Comparison of research funding cited in impact case studies and external income to EPS departments over REF assessment period**

The qualifying period for underpinning research leading to the impacts described was 1 January 1993 – 31 December 2013. During this time the EPSRC spent just under £7.4 billion on research grants. Thus the grants cited within the impact case studies represent ~15% of total EPSRC spend during the qualifying research period.

An analysis of the funding from different sources cited in the impact case studies (Figure 12 overleaf) shows some differences across the sectors (for example the significance of European Union and government department funding for aerospace and defence). Although these figures come with strong caveats, as we know that it is not the complete picture, they nevertheless offer some interesting pointers for further exploration.

# 6 Funding for research underpinning REF impact case studies

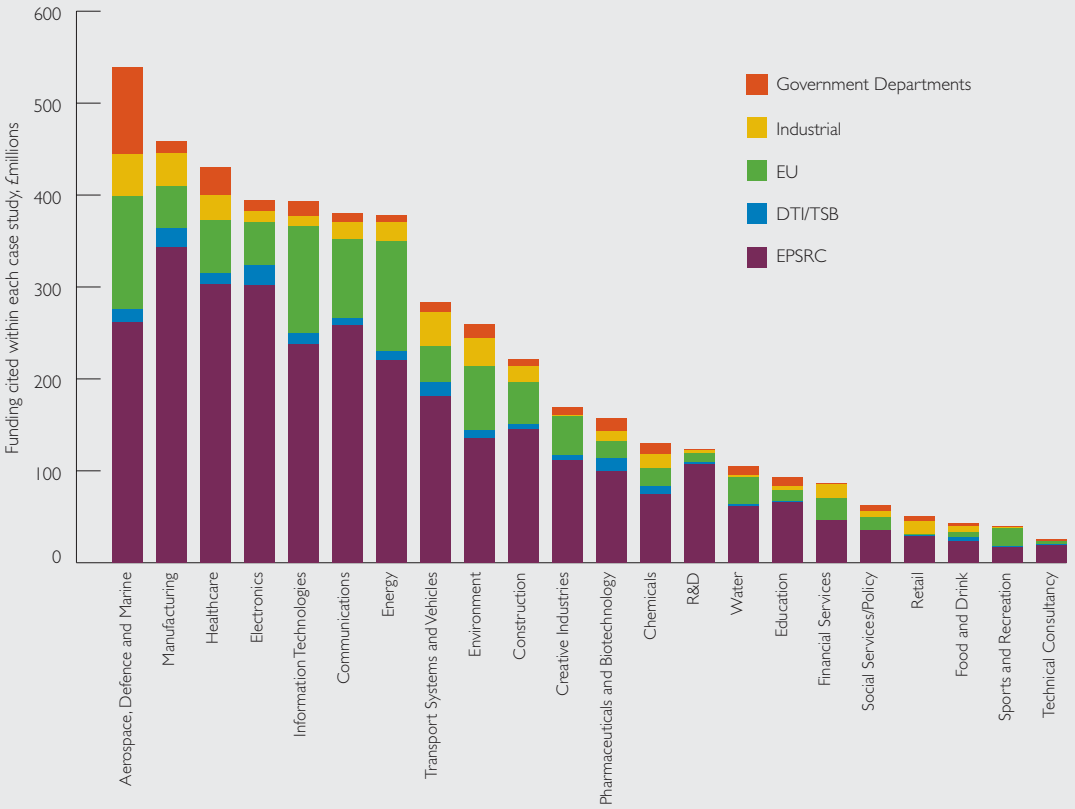



**Figure 12. Distribution of sources of funding cited in impact case studies by sector**

# Nature of cited EPSRC funding

The number of REF impact case studies associated with an EPSRC supported researcher or an EPSRC grant is 1051. For those impact case studies which cite EPSRC support (640, of which 501 actually provide details of grants), the total number of individual grants listed is 1010. As shown in Figures 13 and 14, two thirds of the grants by value (approximately three quarters by number) were 'standard research'[8] grants – just over 70% of these were investigator-led (or 'responsive-mode'), but there were also projects in response to calls for programmes such as Basic Technology, Digital Economy, Healthcare and SUPERGEN[9].

It is interesting also to note the significant role of critical mass funding (such as Science and Innovation Awards, which were EPSRC investments to build capability in strategically important areas) and funding for centres such as the Innovative Manufacturing Research Centres and the Innovation and Knowledge Centres. Although the internal EPSRC analysis identified relatively few references to specific Knowledge Exchange (KE) schemes (with no recorded mentions of Knowledge Transfer Accounts[10]), from a recent study of the impact of these interventions we know that at least nine impact case studies have involved KTA support. It is likely that, because the awards were granted to universities to be allocated centrally, links to EPSRC funding were not explicit. It is also true that references to KTA funding tend to appear in the impact narrative section rather than the underpinning research section where specific grants tend to be cited. A keyword search revealed 22 impact case studies involving KTA support.

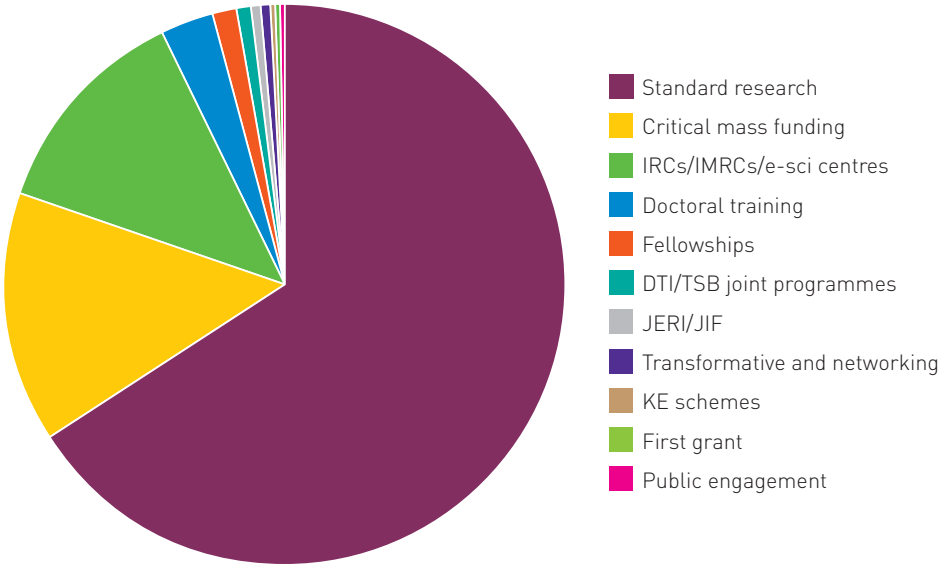



**Figure 13. Types of EPSRC grant funding underpinning research (by value)[11]**

8 *Standard research is that which can be applied for at any time and in any area within the EPSRC's remit by any eligible investigator. The key features of standard grant funding are: no closing dates, no limits on the value or length of the grant, no constraints on the field of research, providing the majority of it falls within the EPSRC's remit, international excellence and national importance.*

9 *SUPERGEN is part of the Research Councils' UK Energy Programme – the first consortia were launched in 2003 and the programme now supports eight consortia and five hubs focused on renewable energy research.*

10 *Knowledge Transfer Accounts (KTAs) were three-year grants awarded to universities to encourage the take-up and further use of the outcomes from EPSRC-funded research. EPSRC invested ~£44 million in 12 KTAs in 2009.*

11 *Analysis of REF Impact Case Studies for UoAs 8-15, Research in Focus Ltd, May 2015 – internal report for EPSRC.*

# 7 Nature of cited EPSRC funding

| Nature of funding | Amount cited as underpinning the impact case studies (£million) | Number of grants mentioned |
|---|---|---|
| Standard research grants | 657 | 756 |
| Critical mass investments[12] | 145 | 65 |
| Joint activity with DTI/TSB/Innovate UK | 8.5 | 37 |
| IKCs/IMRCs/etc, large KE focused centres[13] | 124 | 24 |
| Doctoral training centres | 30 | 7 |
| Fellowships | 12 | 25 |
| JERI/JIF | 6.8 | 11 |
| Support for transformative research and networking/travel | 4.7 | 31 |
| KE schemes (Follow on Fund , KTS) | 4.4 | 19 |
| First grant/fast stream | 2.5 | 23 |
| Public engagement | 0.6 | 12 |

**Figure 14. Number and types of EPSRC grants referenced**

*12 The critical mass investments category consists of: platform grants, portfolio partnerships, programme grants, science and innovation awards, institutional sponsorship, Interdisciplinary Research Collaborations, large research centres and a national service.*

*13 The large KE focused centres category consists of: Innovative Manufacturing Research Centres, Innovation and Knowledge Centres and an e-Science Centre, many of which were jointly supported with the DTI/TSB.*

# Relationship between EPSRC and Innovate UK support

8

Of the 1226 impact case studies within the EPSRC's remit, 171 cite support from Innovate UK (and its predecessors – DTI/TSB. Of these 171, 153 (i.e. ~90%) involve EPSRC supported research/ researchers and of those, 111 explicitly cite EPSRC funding.

Further analysis of the 72 impact case studies which provided details of EPSRC and DTI/TSB funding show that the median time is five years between first EPSRC funding and the DTI/TSB funding (Figure 15).

There are ten impact case studies where EPSRC and Technology Strategy Board (TSB) funding start in the same year - where information was available the funding was either from a joint initiative by the DTI/TSB and EPSRC (e.g. LINK), or the investigator had already been working on a more applied programme of work: Basic Technology Programme, Teaching Company Scheme/ Knowledge Transfer Partnerships and SUPERGEN are all mentioned.

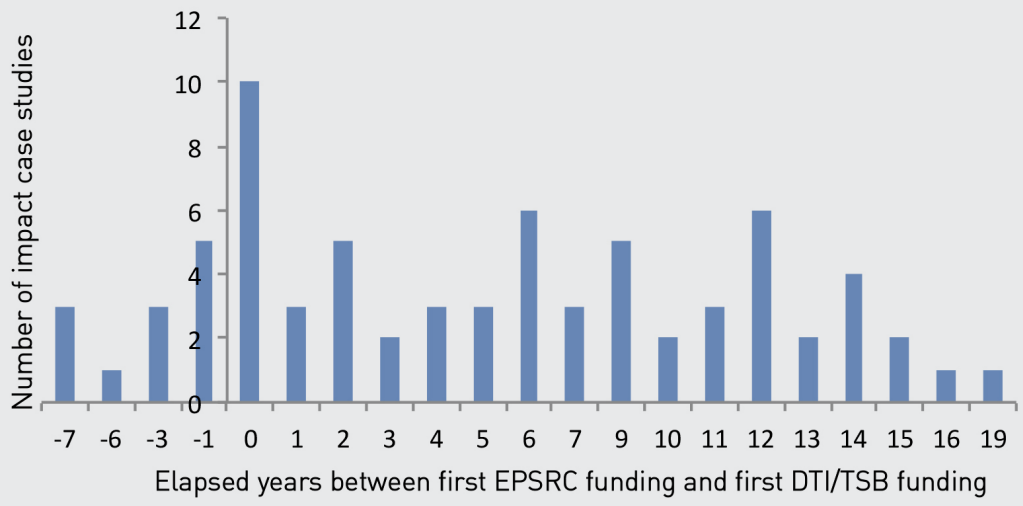



**Figure 15. Elapsed time between first EPSRC funding and TSB/DTI funding**

The pattern of funding for the impact case studies where DTI/TSB and EPSRC funding were received in different years was analysed and shows that the most frequent model involves a series of EPSRC grants prior to the DTI/TSB funding (Figure 16 overleaf). It is noted also that in a few cases the sequence is reversed and DTI/TSB funding is cited in advance of EPSRC support; this fits with our understanding that applied or translational research can stimulate more fundamental research as well as the other way round.

The EU and industry are the most common sources of funding to be found operating in conjunction with EPSRC and DTI/TSB/Innovate UK funding.

Of the 18 impact case studies citing DTI/TSB funding that do not cite EPSRC supported research, the primary funding sources mentioned (in addition to DTI/TSB) are EU and industry (four impact

# 8 Relationship between EPSRC and Innovate UK support

case studies each). Other sources mentioned include other research councils, funding councils and public sector organisations such as the BBC and JISC[14].

Of the 104 impact case studies within UoA 8 – 15 which cite values for DTI/TSB support, EPSRC is also cited more than twice as often as any other additional source of support:

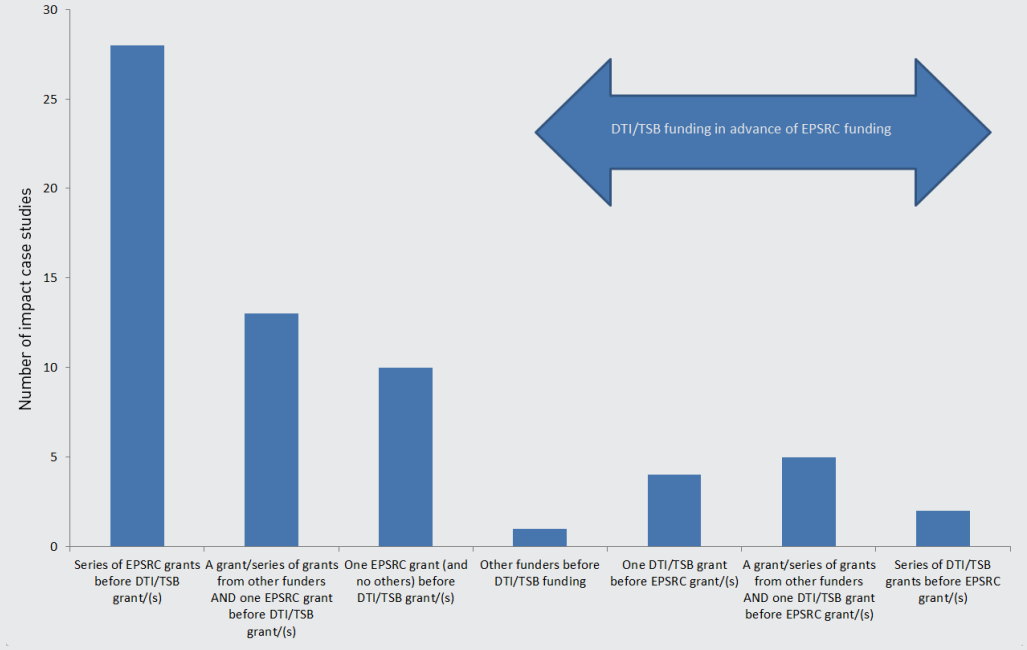



**Figure 16. Time patterns of funding support**

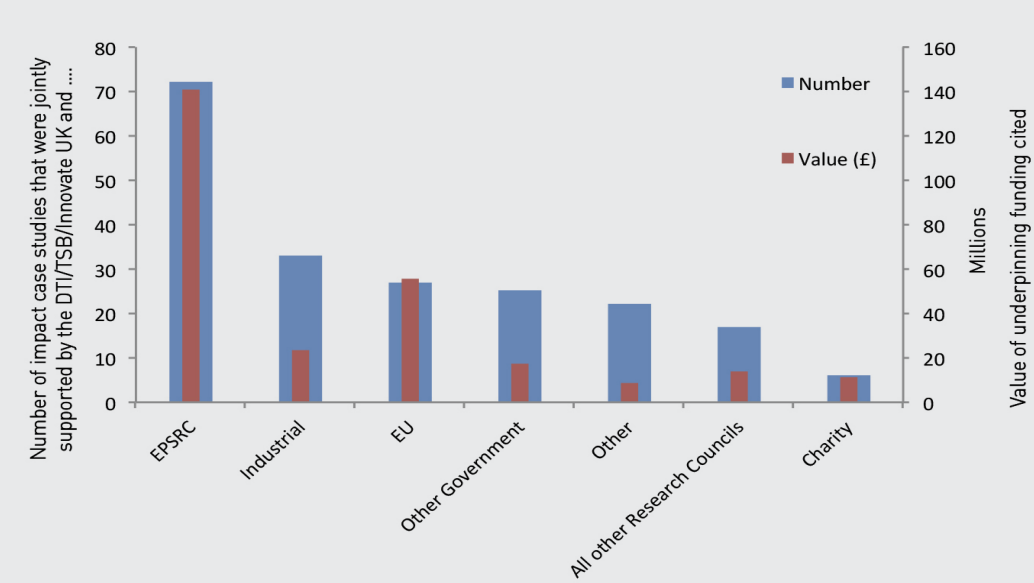



**Figure 17. Frequency of other funding sources associated with DTI/TSB cited support**

*14 JISC is a non-departmental public body established to provide leadership in the use of information and communications technology (ICT) in higher education.*

# Relationship between EPSRC and government departments

9

Of the 1226 cases within the EPSRC's remit, a total of 198 feature support from other government departments (i.e. other than RCUK/TSB/etc, support via BIS) and of these, 86% (171) are connected to EPSRC supported research/researchers. The value of the cited grants received from government departments associated with the 171 cases which involve EPSRC research/researchers is ~£174 million, out of the total funding of £473 million listed in these impact case studies.

The distribution of government departments cited in the 171 cases which are connected to EPSRC supported research/researchers is shown by value of contribution and number of grants cited – (Figure 18a and 18b); it can be seen that nearly two-thirds of the total financial contributions listed have come from the Ministry of Defence (MoD). The majority of the MoD funding is associated with the Aerospace and Defence Sector (£84 million out of the total £94 million government funding for this sector). The distribution of funding by government departments across the other sectors is shown in Figure 19 overleaf.

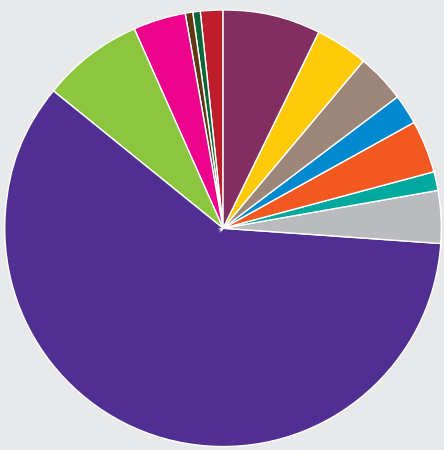


**Figure 18a. The value of grants cited from government departments by impact case studies involving government department support and EPSRC research/researchers.**

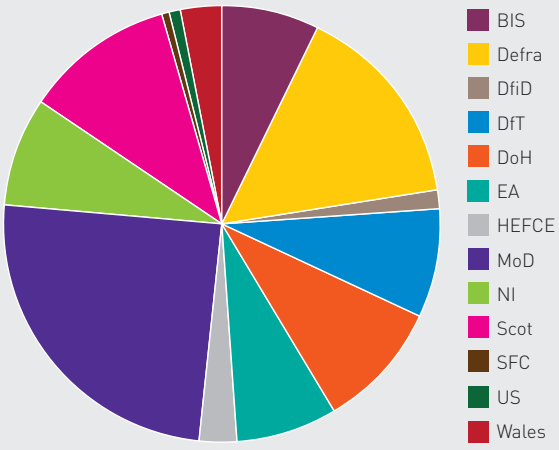



**Figure 18b. The number of grants cited from government departments by impact case studies involving government department support and EPSRC research/researchers[15].**

The most frequently cited department is the MoD (and associated agencies such as the Defence Science and Technology Laboratory (DSTL); 41 of the impact case studies mention MoD funding, of which all except one involve EPSRC-supported research/researchers. A significant proportion involve materials research and development, for example, materials with improved performance and reliability and functional materials such as liquid crystals and carbon nanotubes. Other areas include non-destructive testing, laser technologies, wireless and communication technologies and modelling of real-world phenomena. Of the 21 impact case studies which mention support from the Department for Environment, Food and Rural Affairs (DEFRA), 20 were also linked with EPSRC support; the most common areas of research involve improving efficiency and reducing environmental impact in industry, through equipment maintenance

*15 Some double counting will occur where more than one government department was mentioned.*

# 9 Relationship between EPSRC and government departments

strategies, reducing and troubleshooting risk, asset management planning and reducing energy consumption. Eighteen of the impact case studies cite funding from the Department for Business Innovation and Skills (BIS), with all except one involving EPSRC support as well. Commonest areas of research involve reducing fuel consumption and emissions in industry, development of recyclable plastics and new healthcare technology.

Fewer impact case studies cite support from the Department of Health (DoH) or the Department for Transport (DfT) (eight for each). The DoH support is for areas such as the development of microtechnology for sample analysis, use of microwaves for treatment, biological scaffolds and medical monitoring technology. For the DfT, areas supported are most commonly addressing issues of transport efficiency, for example improving rail infrastructure efficiency and capability.

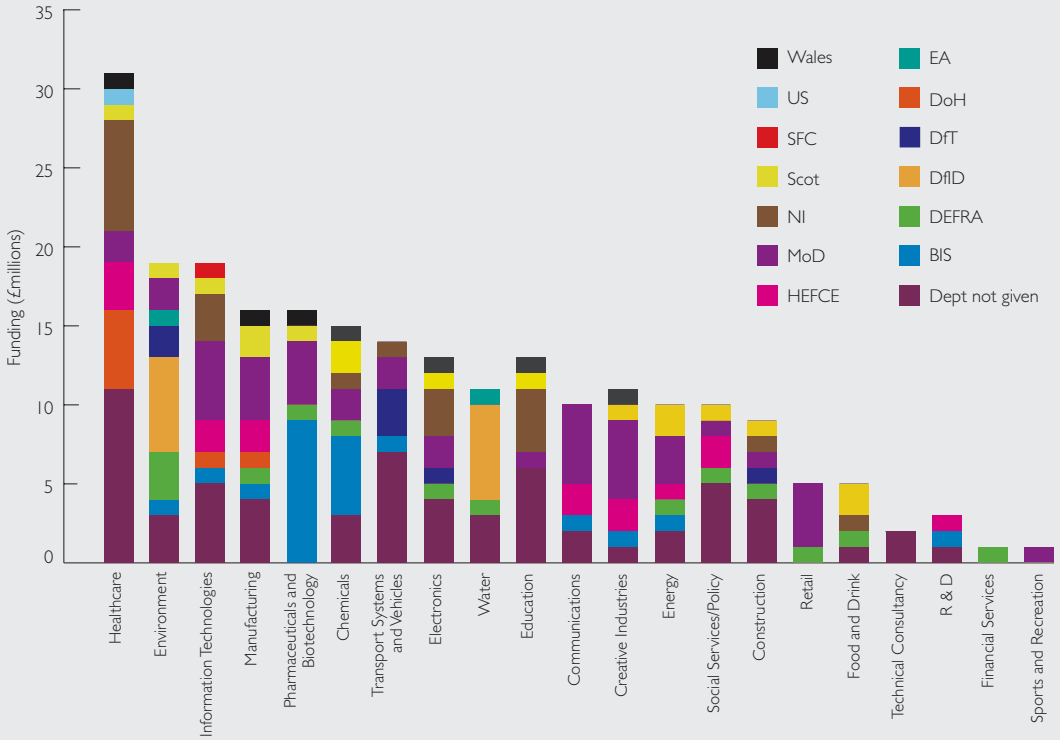



**Figure 19. Funding contributed by government departments – analysis by sector (excluding Aerospace and Defence)**

# EPSRC and multidisciplinary research

10

EPSRC is mentioned in 943 impact case studies from the total set of 6642 (i.e. ~14% overall)[16], more than any other project funder, across 30 out of the 36 UoA from all of the four main panels. This includes 56 impact case studies from Main Panel A (health and life sciences), 142 from Main Panel C (economic and social sciences) and 53 from Main Panel D (arts and humanities) as well as the 693 from Main Panel B. Of the 943 impact case studies citing EPSRC, the involvement of other funding bodies is shown in Figure 20.

| Funder | Number of impact case studies |
|---|---|
| AHRC | 48 |
| BBSRC | 62 |
| ESRC | 72 |
| MRC | 55 |
| NERC | 53 |
| RAEng | 30 |
| Royal Society | 139 |
| STFC (+ PPARC and CCLRC) | 41 |
| Wellcome Trust | 41 |

**Figure 20. Involvement of other funders in impact case studies referencing EPSRC**

From our internal analysis of the 1226 impact case studies within EPSRC's remit, 347 (i.e. 28%) are recorded as involving two or more disciplines; however, this is likely to be a conservative estimate as this is based on the information given in the underpinning research section and the disciplines of the researchers involved were not always included.

Twenty-two of the impact case studies analysed cite support from BBSRC (38 references) and 19 mention support from MRC (22 references). Fifty-nine impact case studies listed support from other research councils.

For the impact case studies for which sufficient information was available, the time gap (in years) was analysed between first funding by EPSRC and first funding by another research council. For the 55 impact case studies which gave funding dates, 19 cite funding received from other research councils first and 32 report EPSRC funding followed by support from other research councils. The time relationships between EPSRC and other research council funders is shown in Figure 21 overleaf.

*16 Based on the searchable database provided on the REF 2014 website.*

# 10 EPSRC and multidisciplinary research

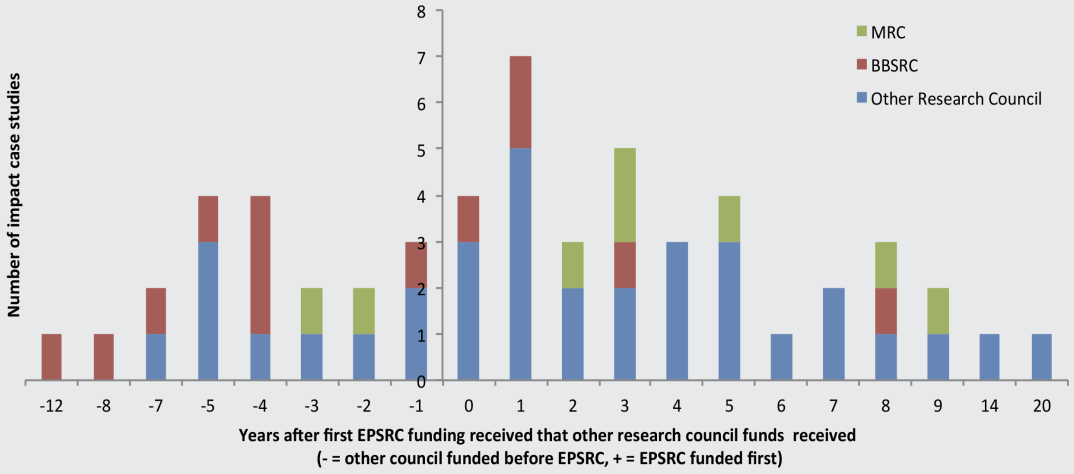



**Figure 21. Time relationships between funding from EPSRC funding and other research councils**

# 11 International collaboration

Of the 1226 case studies in the EPSRC remit, there were 333 which recorded international collaboration with academic researchers in other countries (i.e. 27%). As might be expected, the commonest partners were other European countries and the US, but there was also a reasonable distribution across other countries such as China, Japan and the rest of Asia, with Asian and Australasian countries tending to be involved as collaborating partners more frequently than the South American countries such as Brazil (Figure 22).

| Countries | Number |
|---|---|
| | 243 |
| Africa | 7 |
| Australasia | 12 |
| Brazil | 2 |
| Canada | 2 |
| China | 38 |
| Europe | 81 |
| Europe (other than UK) | 132 |
| India | 9 |
| Japan | 21 |
| Other | 28 |
| Rest of Asia | 15 |
| Rest of South America | 3 |
| Singapore | 1 |
| Ukraine | 1 |
| USA | 115 |

**Figure 22. Frequency and distribution of international collaboration cited**

# 12 Industrial collaboration and funding

Of the 1226 impact case studies within EPSRC's remit, 44% involve industrial collaboration; a figure which strongly aligns with the proportion of EPSRC's portfolio that is collaborative with users. The pattern of collaboration across sectors is shown in Figure 23.

Of the impact case studies involving industrial collaboration, nearly a quarter (i.e. 129) involve organisations with which EPSRC has developed a strategic partnership.

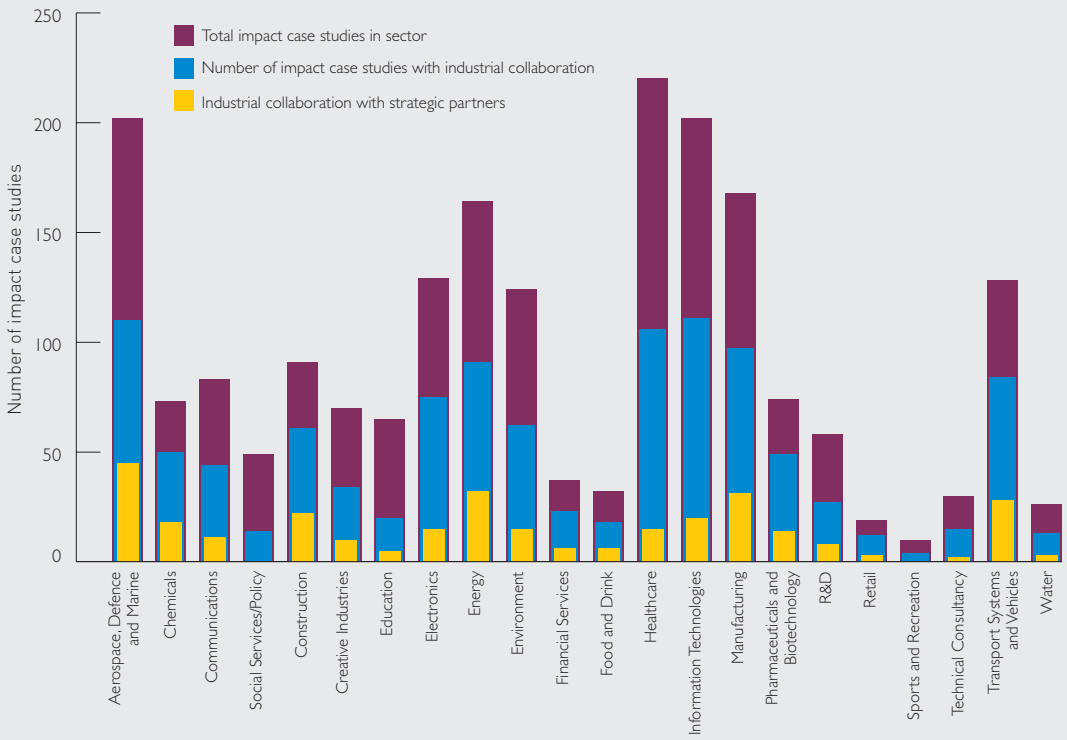



**Figure 23. Number of impact case studies involving industrial collaboration by sector**

Approximately 20% of the impact case studies cite industrial funding – the distribution by sector is shown in Figure 24. Of the total industrial contributions listed (~£150 million), approximately 20-25% come from EPSRC strategic partner organisations, although the nature of the data means that this mapping could not be achieved exactly. Nevertheless, it reinforces the extent to which EPSRC is partnering with the key organisations within the research and innovation landscape.

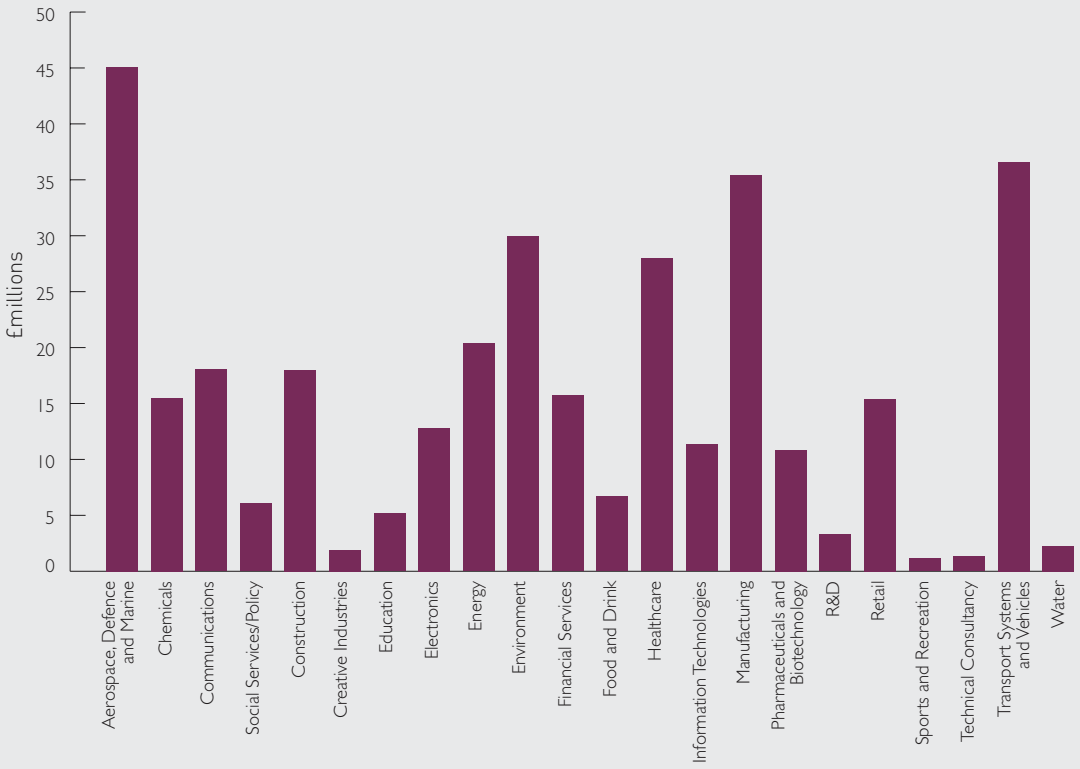



**Figure 24. Levels of industrial funding by sector**

# 13 Economic impacts

Where possible, quantitative information on economic and other impacts was captured using a structured approach. As has already been highlighted, the information has not been independently verified for this analysis, although a number of the impact case studies were audited as part of the REF assessment process. Nevertheless, they provide a useful basis on which to draw general conclusions regarding orders of magnitude of impact.

## Cost savings

One of the main types of economic impacts reported is cost savings; in total 230 impact case studies reported cost savings of which the majority (211, i.e. 92%) involved EPSRC-supported research/researchers. Of the 159 impact case studies which provided a value for cost savings, 94% (i.e. 150 out of 159) are associated with EPSRC funding and an even higher proportion of the actual cost savings cited (£16.2 billion out of a total of £16.4 billion, ie 98%) is linked to EPSRC support. Our analysis focused on the impact case studies associated with EPSRC supported research/researchers; of the total £16.2 billion cost savings cited, £10.3 billion are in the private sector and £5.9 billion in the public sector. There are significant uncertainties around these figures; however as the figures recorded were minimum figures based on the information available in the impact case studies, we can be confident in stating that they are generally conservative and the actual cost savings will be considerably higher.

The distribution of cost savings broadly reflects Zipf's law, with a few impact case studies reporting the bulk of the cost savings, and a long 'tail' of impact case studies with similar, lower levels of cost savings (Figure 25 below).

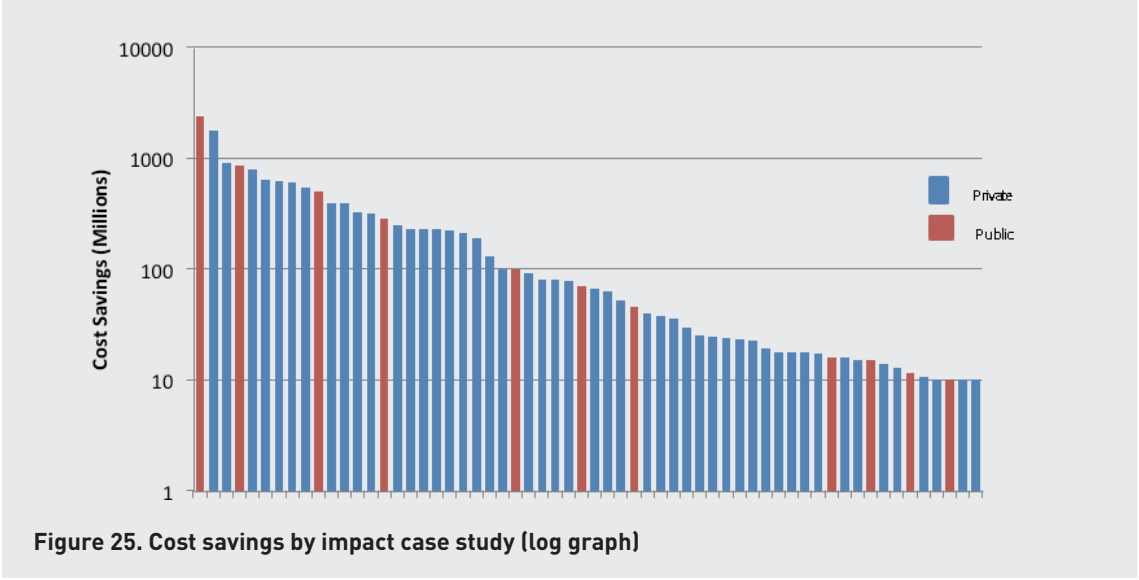



**Figure 25. Cost savings by impact case study (log graph)**

An analysis of the distribution of cost savings by sector is shown in Figure 26 – it can be seen that the highest levels of private sector cost savings is in energy, manufacturing, aerospace, defence and transport, whilst for the public sector the most significant savings are associated with healthcare.

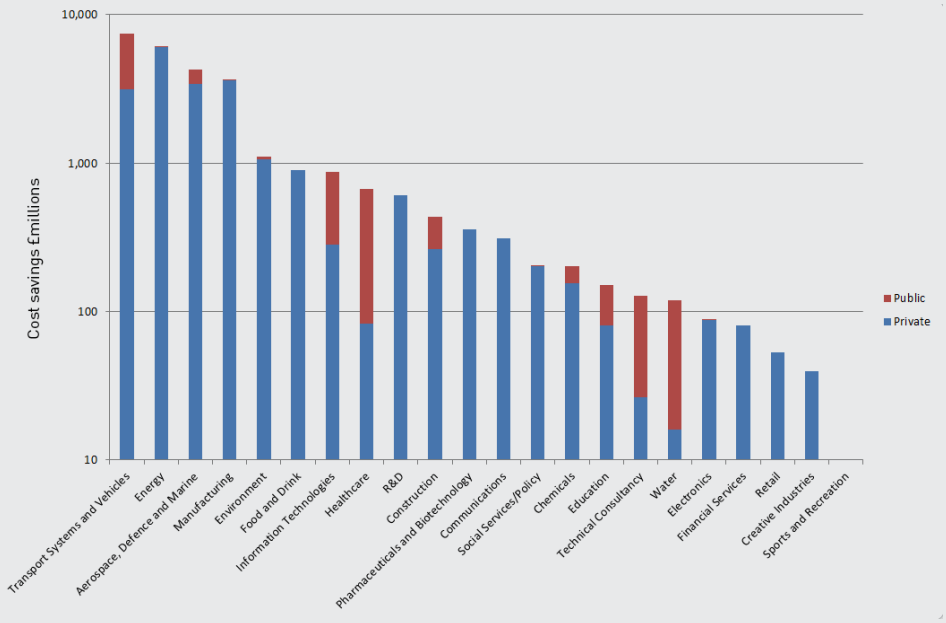



**Figure 26. Cost savings by sector (log graph)**

## New business creation

Spin-out companies are a common method through which universities can take forward the outcomes of research, for example through the further development of technologies and products. Analysis of the 1226 impact case studies in EPSRC's remit identified 394 spin-out companies associated with EPSRC supported research/researchers, of which 154 (~40%) were already known to EPSRC. The distributions by sector and by UoA are shown in Figures 27 and 28 overleaf.

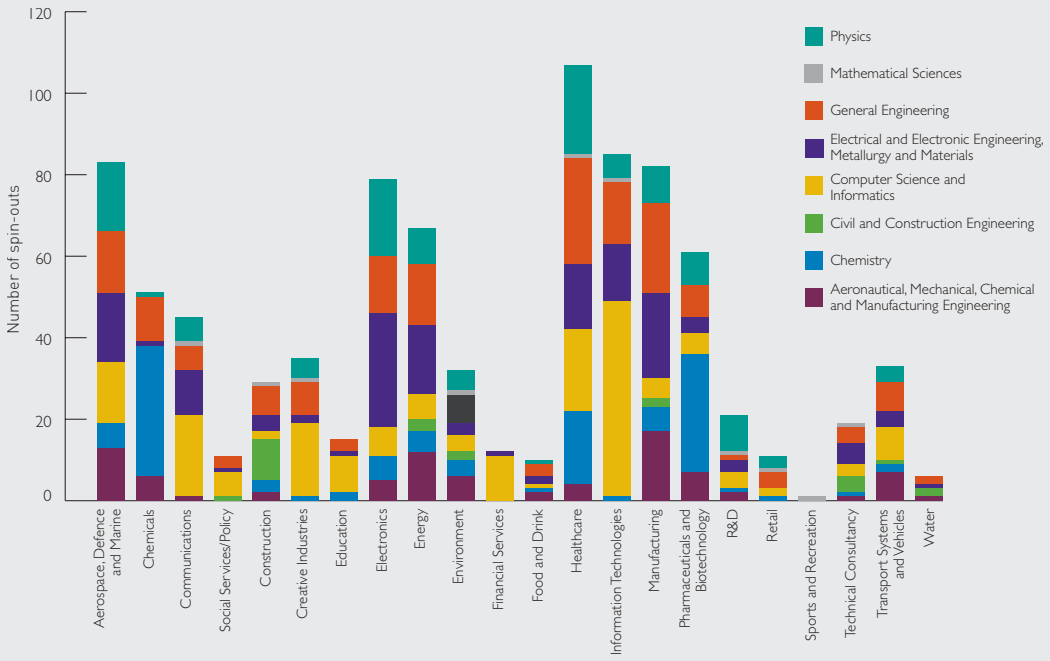



**Figure 27. Number of spin-outs by sector (showing distribution by UoA within each sector)**

# 13 Economic impacts

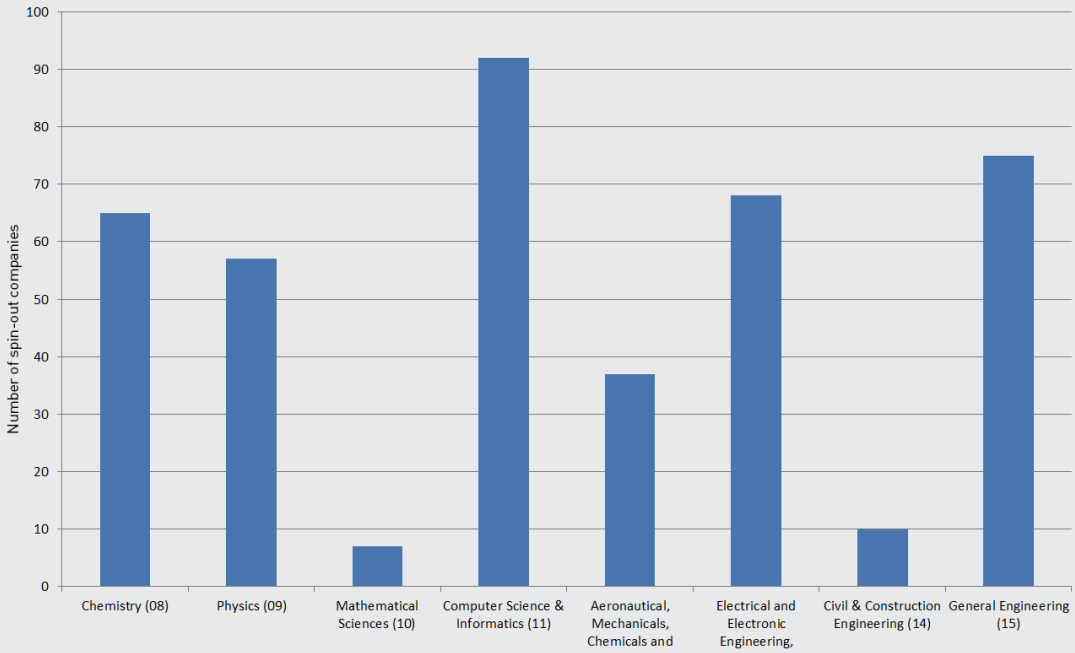



**Figure 28. Number of spin-outs by UoA**

An analysis of these spin-outs was undertaken using information provided in the impact case studies, augmented with additional information from other sources, including:

- Companies House (a UK government executive agency which stores all legally required company information as a register, which can be accessed online).
- The spin-out company websites.
- Spin-outs UK (an online database of more than 1500 university spin-out and start-up companies).
- Endole & Company Check (websites which provide corporate information on UK companies).

Of the 394 spin-out companies identified, 87% are currently active ('effective' or 'trading'); the companies have a high survival rate – nearly 94% of the companies have been active for over three years and 85% have been in existence for five years or more. This is perhaps to be expected, as these represent the 'success stories', though it is interesting to note that a similar figure was derived from an internal EPSRC study in 2010 which concluded that 83% of spin-outs reported from EPSRC-funded projects had a survival rate of three years or more.

Employee numbers were obtained for approximately half of the spin-out companies (198); the total coming to 23,677. With the assumption that the value for number of employees in this half of the total group can be taken as representative of the other half, it can be estimated that the gross number of jobs created by the 394 spin-out companies is around 47,000. Figure 29 shows the distribution of employee numbers: the largest single category is 11-50 employees. Of the companies with submitted employee data, 195 (98%) have less than 250 employees and are categorised as SMEs.

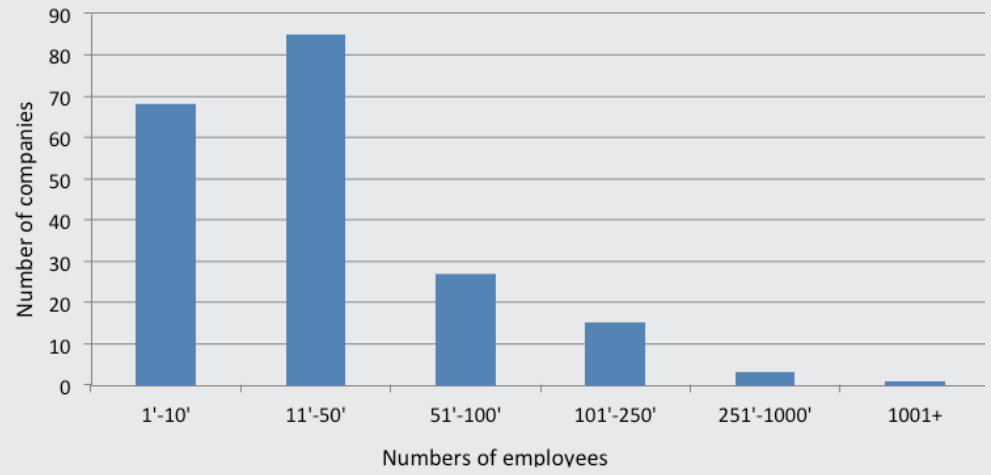



**Figure 29. Distribution of employee numbers reported**

The number of companies submitted with values for annual turnover is 112 (28.4%), producing a total of £1.12 billion. The distribution of spin-out turnover levels is shown in Figure 30. Assuming that the annual turnover for this group of spin-outs can be taken as representative of the whole group, we estimate that the gross annual turnover for the 394 spin-out companies is within the region of £4 billion.

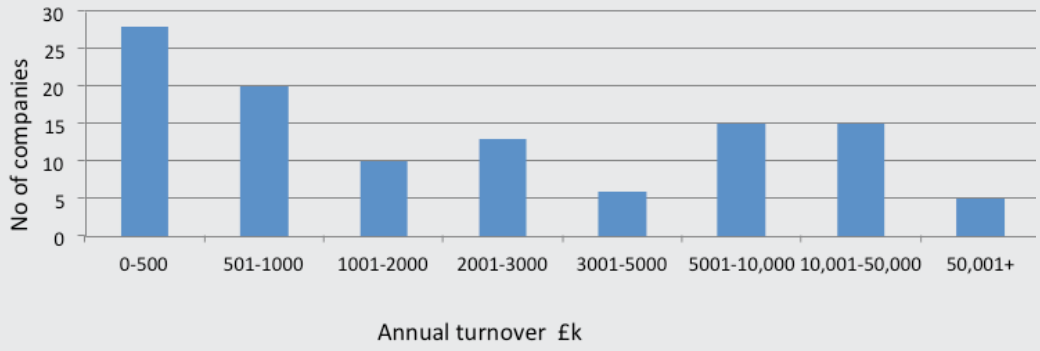



**Figure 30. Distribution of spin-out turnover figures**

## Additional sales and other economic activity

Of the total 1226 impact case studies, 159 cite impacts on existing businesses from additional sales revenue through the development of new technologies, processes or products (of which there are nearly 950 examples given). Out of the 159, 141 impact case studies involve EPSRC supported research/researchers; these impact case studies reported £61.1 billion, i.e. 99% of the total additional sales of £61.7 billion. As with all aspects of this analysis, the figures must be viewed in context: a range of approaches were used for deriving quantitative estimates, and the extent to which these can be directly attributed to the research developments are also highly variable. Nevertheless, they provide an indication of the scale of economic activity associated with the research referenced in the impact case studies. As with cost savings, the picture is of a highly skewed distribution which can be seen from the log graph in Figure 31 overleaf.

# 13 Economic impacts

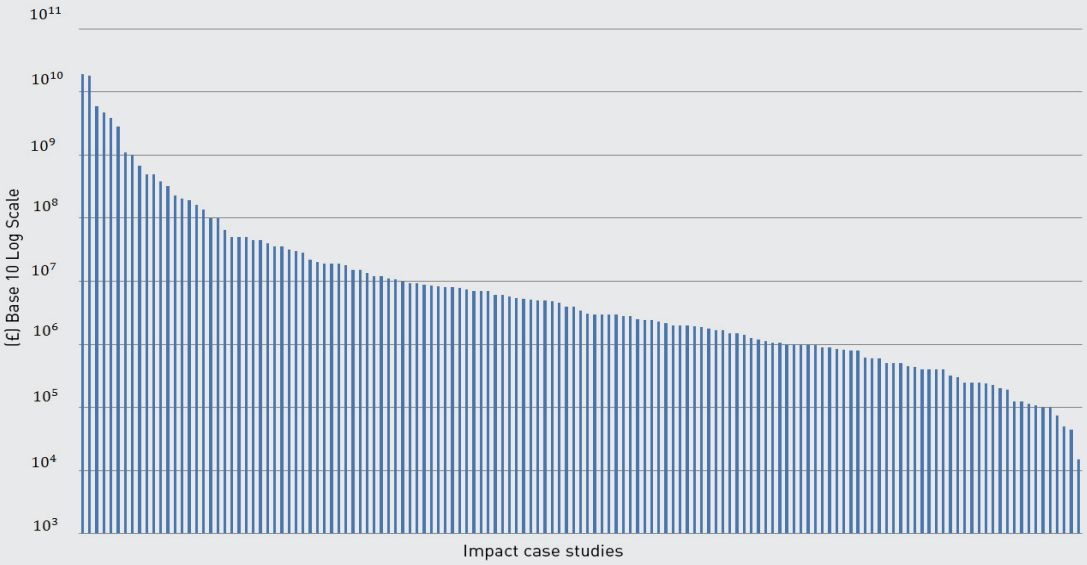



**Figure 31. Distribution of additional sales revenue (log plot)**

Analysis by sector shows the highest overall values are associated with sectors such as energy, electronics, IT and manufacturing (Figure 32).

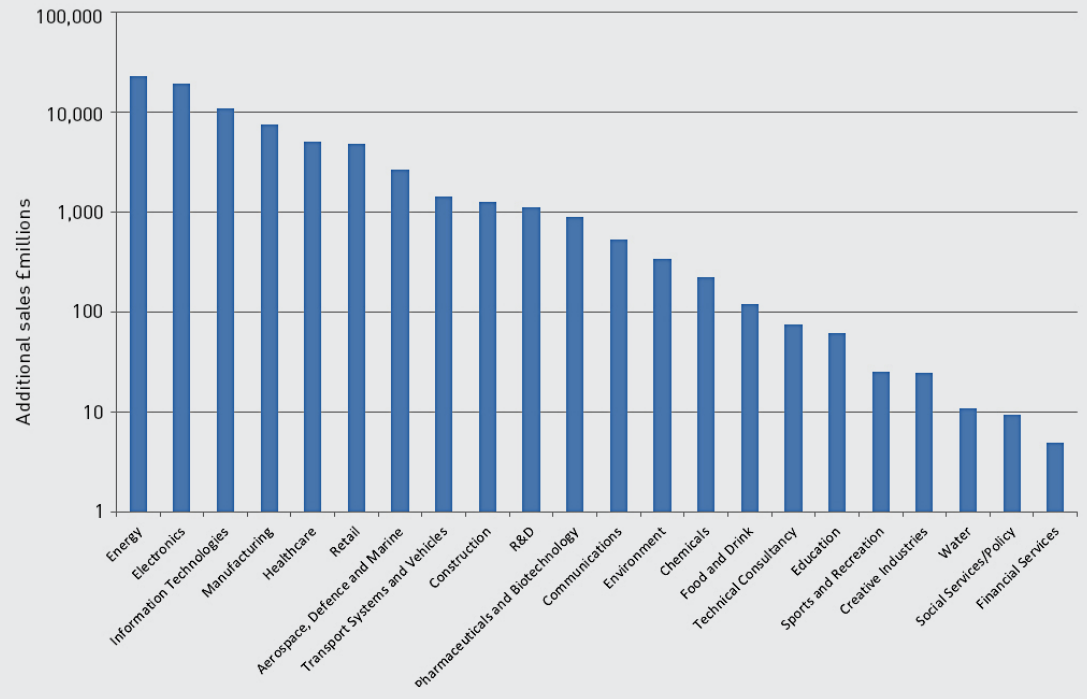



**Figure 32. Values of additional revenue by sector**

Examples include:

- Additional revenue from electricity generation from advanced gas-cooled reactors due to extended lifespan, based on development of new techniques for monitoring their structural integrity.
- Sales of hard disk drives using redesigned read heads based on insights from previous research.
- Increased diamond sales based on consumer confidence arising from the development of better techniques for identifying authenticity.
- Boosted sales of a high-end sports car which benefits from a novel carbon fibre manufacturing process.
- Additional sales arising from increased production of an active pharmaceutical agent through the development of a continuous manufacturing process.
- Commercial advantage through computational discovery of dynamic communicators in large digital networks.

## Policy and public sector impacts

Over 350 examples of impacts on policy/public sector are cited; the distribution of these is shown in Figure 33. The highest numbers of impact case studies reporting such impacts are in the healthcare, information technologies and environment sectors.

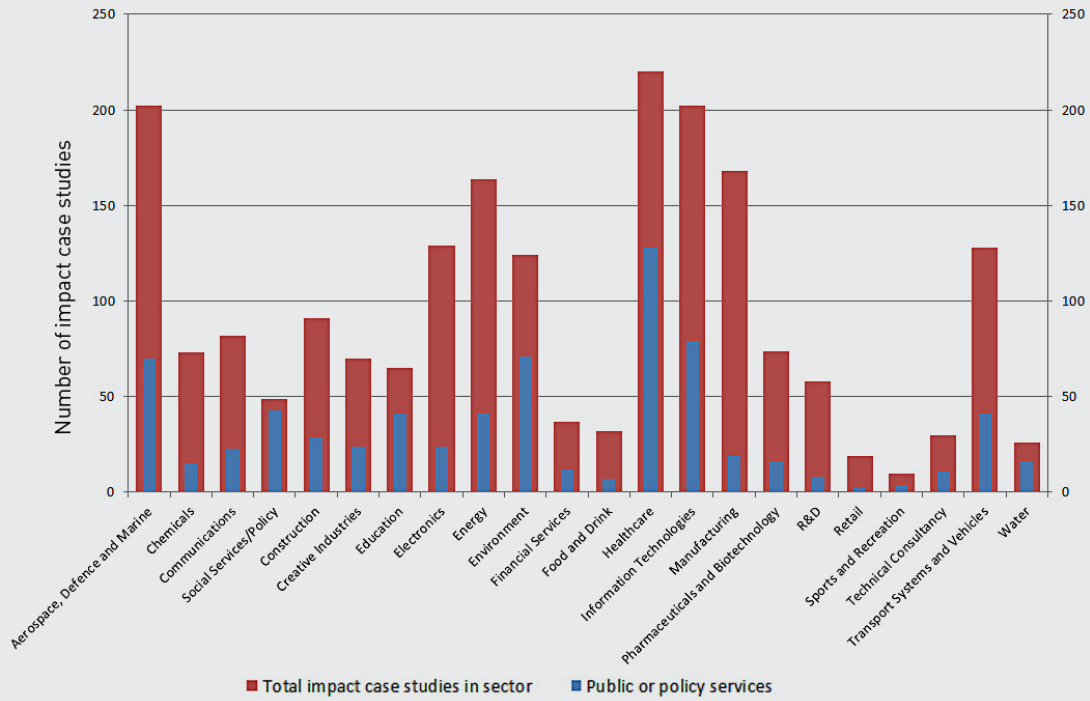



**Figure 33. Numbers of impact case studies citing public services/policy impact by sector (impact case studies can be relevant to more than one sector so this will include multiple counting)**

# 13 Economic impacts

## Environmental impacts

Overall 273 examples of environmental impacts are cited. The distribution of these is summarised in the table below:

| Type of environmental impact | Number of instances |
|---|---|
| Energy savings | 83 |
| Reduced emissions | 97 |
| More efficient use of resources | 131 |
| Other | 65 |

Other environmental impacts include: environmentally friendly production (e.g. of Perspex), replacement of heavy metal catalysts in the plastics industry, reduced environmental noise, reduction of non-degradable waste from used plastic food packaging materials, controlling the spread of diseases such as sudden oak death and strengthening air pollution standards.

## Societal impacts

Approximately one quarter (305) of the impact case studies reported societal impacts. These covered a wide range of examples including:

- Chemical research on solvent effects on East Asian lacquers enabled conservation of a historical lacquered chest which could then be toured around museums.
- Reducing homelessness through the use of a mathematical model of housing allocation.
- Safeguarding children through online child protection based on digital personal analysis.
- Cultural impact of dance room Spectroscopy (dS) which allows people to literally step into an interactive molecular dynamics simulation.
- Proceeds from the sale of super-repellent technology used to help alleviate extreme child poverty in India and Africa.
- Increased interest in science and higher uptake at post-16 level through use of chemistry education packages in schools.

## Time to impact

In order to explore the time intervals for impact, we analysed the start dates of the earliest EPSRC grants referenced in the impact case studies. There are significant caveats in terms of the constraints of the REF reporting timeframes and the fact that not all the relevant grants will have been cited, but the resulting distribution does highlight the broad range of timescales over which impact can be delivered (Figure 34).

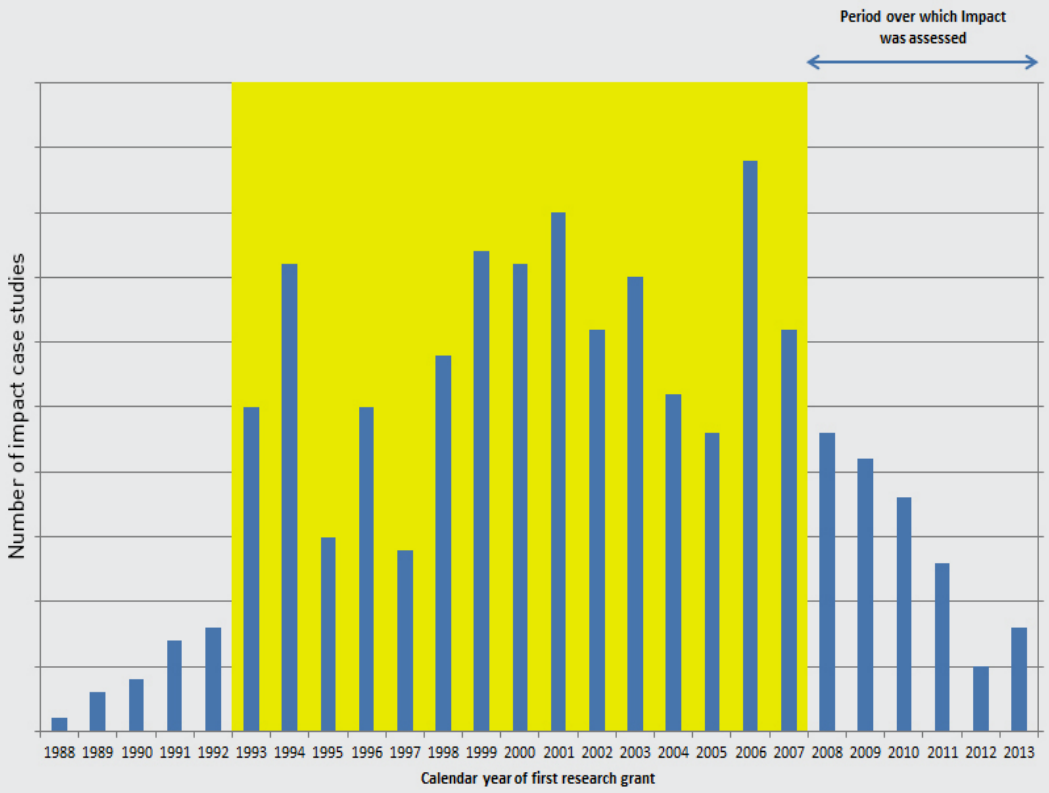



**Figure 34. First date of EPSRC research funding cited in impact case studies**

# 14 Conclusions

This analysis of the impacts reported in the REF impact case studies in the EPS subjects has allowed us to understand how EPSRC investments over the last two decades have delivered benefits across many areas of the UK economy and society. There were significant challenges in extracting information, particularly quantitative, in a systematic way. We have drawn on other sources, such as EPSRC's grant management information and contextual data provided by HESA, to maximise the value of the analysis. For example, by matching researcher names to EPSRC grants data, we have been able to partially address the lack of consistency in references to funding sources: using this approach we have identified 34% of the impact case studies with links to EPSRC funding in addition to the 52% of impact case studies which cite EPSRC specifically. However, this demonstrates the extent to which key funding sources have been under-reported and reinforces the requirement for more structured provision of information in REF impact case studies in future exercises.

Within the limitations of the funding information provided in the impact case studies, it is still possible to draw some interesting conclusions about the importance of long-term sustained funding for the underpinning research, through a range of mechanisms including 'investigator-led' (or 'responsive-mode') and 'critical mass investments', such as the Innovative Manufacturing Research Centres or the Innovation and Knowledge Centres. This is particularly significant in the context of EPS, where it is clear that research council funding is the main source of external income for university research, accounting for 44% on average across EPS disciplines.

It is also notable that the majority of the impact case studies which cite support from Innovate UK (or its predecessors) also involve EPSRC funded research or researchers. This highlights the way in which the innovation system operates most effectively with multiple, complementary funders. It also clearly demonstrates the role of EPSRC in maintaining a vibrant community of researchers actively pursuing excellent research, which not only adds to the academic knowledge base, but also provides a steady flow of new ideas which others can also take forward to application.

One of the aims of this analysis was to explore the extent to which it was possible to derive an overall estimate of aggregate impact based on the quantified impacts reported. Although a sufficient number of the impact case studies provide quantified impacts to enable some analysis, the basis on which these were derived was not consistent. Nevertheless, we have been able to derive overall figures which provide an indication of the order of magnitude of impacts reported, though it is not possible to obtain an annualised figure, or to determine the level of attribution. There is scope for significantly greater levels of guidance on this in future REF exercises. Although we recognise that there will only ever be a subset of impacts that can be quantified, it would be extremely beneficial to ensure a greater level of consistency in the future (for example, based on the Treasury Magenta book), particularly with regards to additional revenue and to cost/efficiency savings, where there are significant success stories to report.

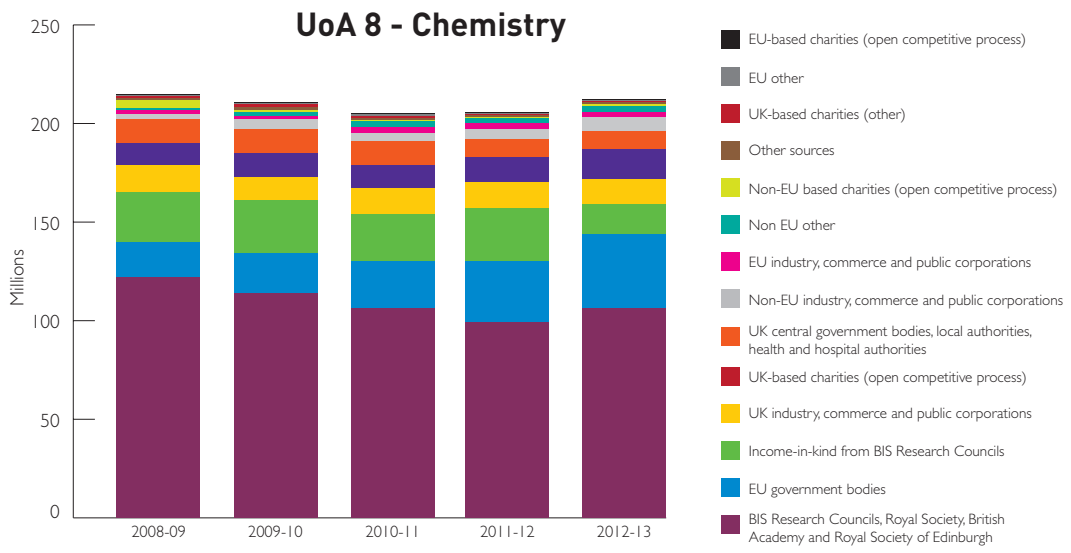
Although for the purpose of this analysis, we focused primarily on the impact case studies within the EPS UoA, we are aware that a significant number of impacts reported in other areas have also benefitted from EPSRC support, and we intend to explore these in more detail in the future, as well as continuing to focus on further analysis of the EPS impact case studies. In common with others who have sought to extract additional insights from the impact case studies, we have found the lack of a consistent format to be a significant challenge. We addressed it as far as possible, using a manual approach to extracting and structuring the information in a more suitable format for analysis. This exercise has provided us with a good understanding of ways in which the information could be more effectively provided in future exercises and we look forward to sharing our insights with those tasked with developing the next REF. Nevertheless, despite the limitations, the REF impact case studies have provided a rich source of information, enabling us to gain interesting insights into the breadth and significance of impacts arising from engineering and physical sciences, which are benefitting all areas of the UK economy and society.

# Annex 1

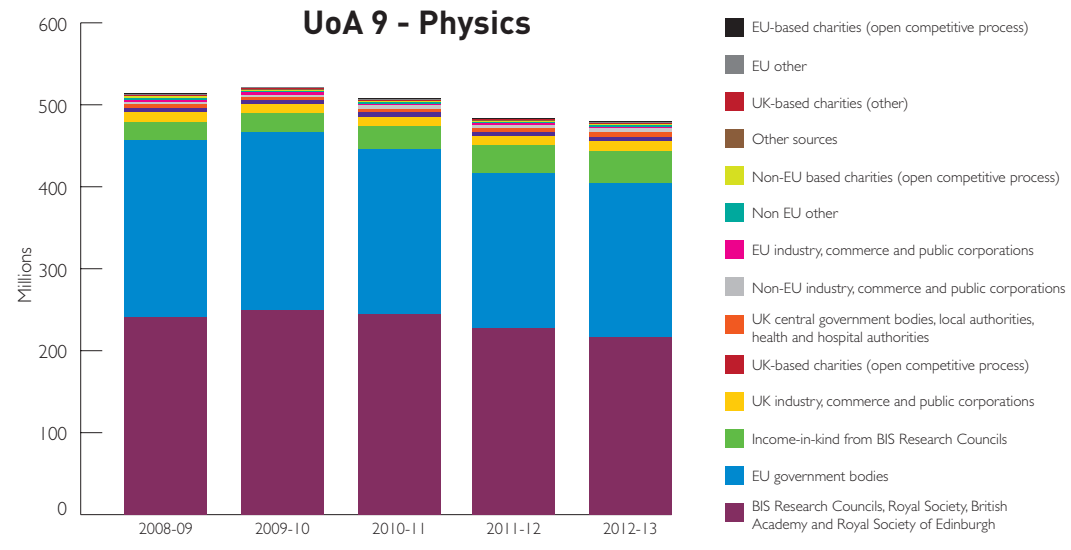
## REF impact case studies – outline analytical framework

| Questions | Data gathered |
|---|---|
| What proportion of REF impact case studies in areas of EPSRC sciences involve EPSRC-funded research? | Sources of funding cited |
| Are there any discernible patterns of funding from different sources, for example the relationship between EPSRC funding and support from other organisations, including Innovate UK? | Sources of funding cited and additional information including dates, values etc |
| Is it possible to deduce anything about the use of specific funding mechanisms, including support for Knowledge Transfer activities? | Information on funding mechanisms cited |
| What conclusions can be drawn about the role of collaboration, national and international (including academic/industrial and academic/academic) in delivering impact? | Collaborations cited |
| Are there any discernible patterns of EPSRC involvement with sectors of the economy and the 'Eight Great Technologies'? | Relevance to:<br>EPSRC sector<br>BIS sector technologies |
| What have been the benefits to the economy (quantified where possible)? | Business improvement, creation of new businesses<br>Jobs created/safeguarded<br>Technologies/products<br>Additional sales<br>Cost savings<br>Inward investment<br>Safety/risk management<br>Regulatory/standards (e.g. informing new standards)<br>New business created (e.g. spin-out) |
| What have the public policy and services benefits been and to what extent has EPSRC played a role in these? | Type of public service<br>Jobs created/safeguarded<br>Cost savings<br>Other benefits (e.g. through more efficient processes) |
| What have the environmental benefits been and to what extent has EPSRC played a role in these? | Type of environmental benefit |
| What have the broader societal impacts been and to what extent has EPSRC played a role in these? | Societal impacts including public engagement |
| Which are the main routes by which impact has been delivered? | Impact routes |
| What can we learn about the time from research to impact? | Information on first grant funding cited |

## External income over REF period

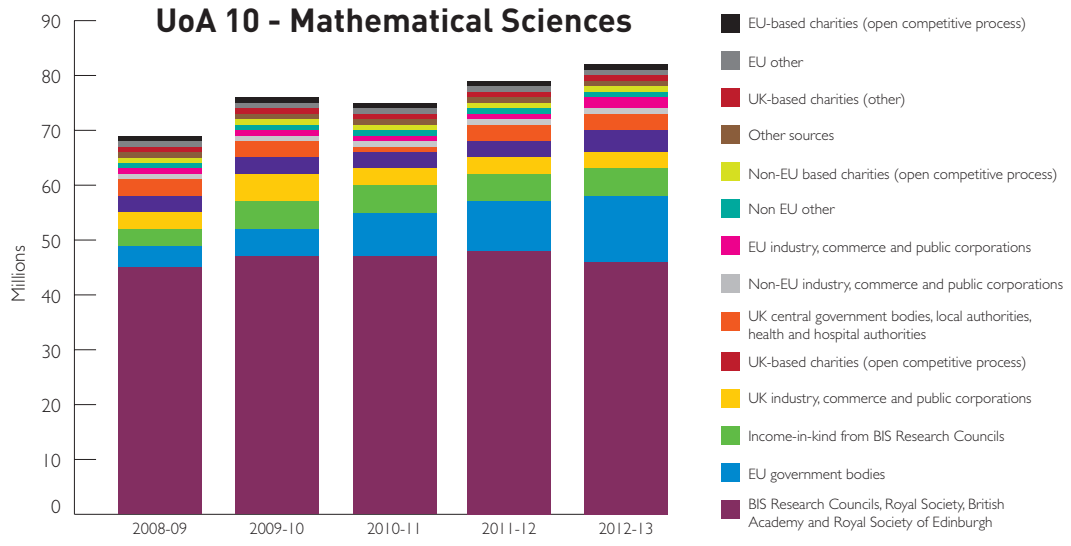



*Note: Research income (£) in 2012-13 prices.*

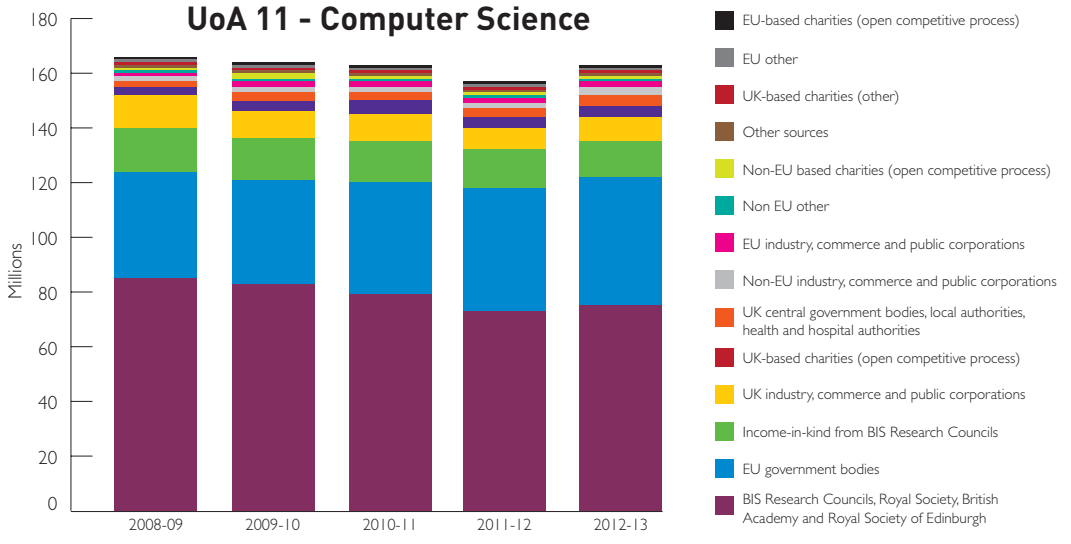



*Note: Research income (£) in 2012-13 prices.*

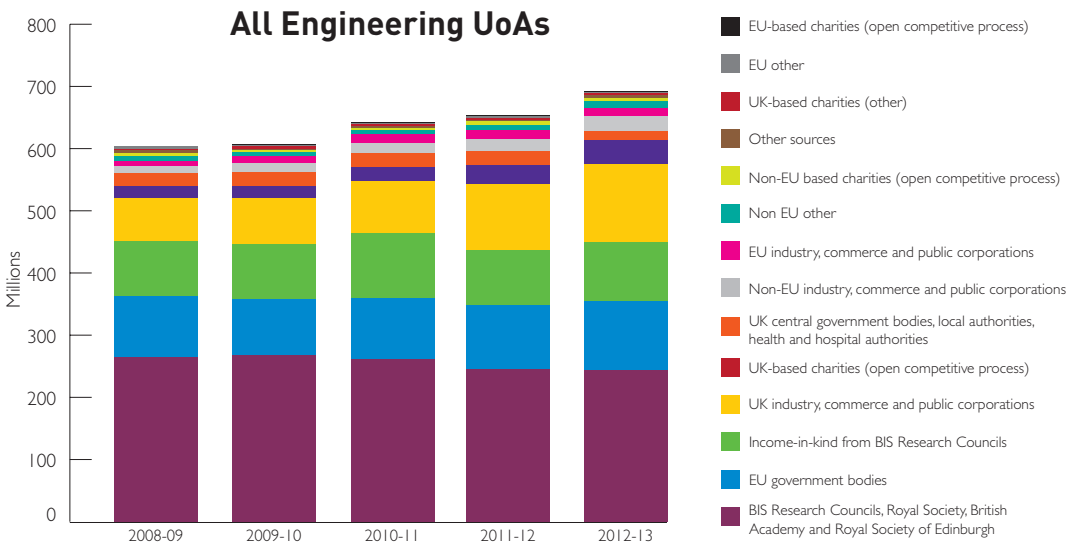
# Annex 2




*Note: Research income (£) in 2012-13 prices.*




*Note: Research income (£) in 2012-13 prices.*

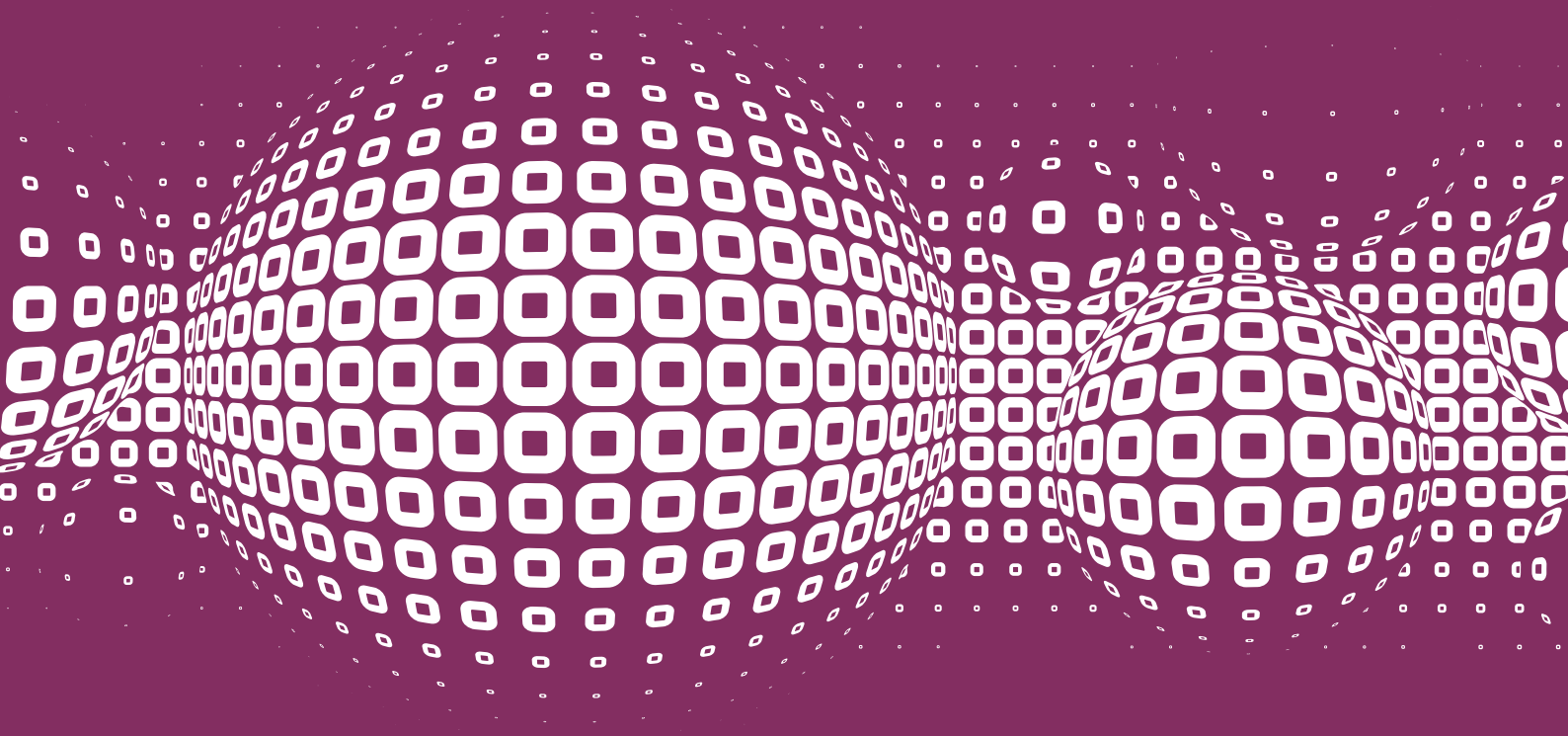



*Note: Research income (£) in 2012-13 prices.*

# Annex 3

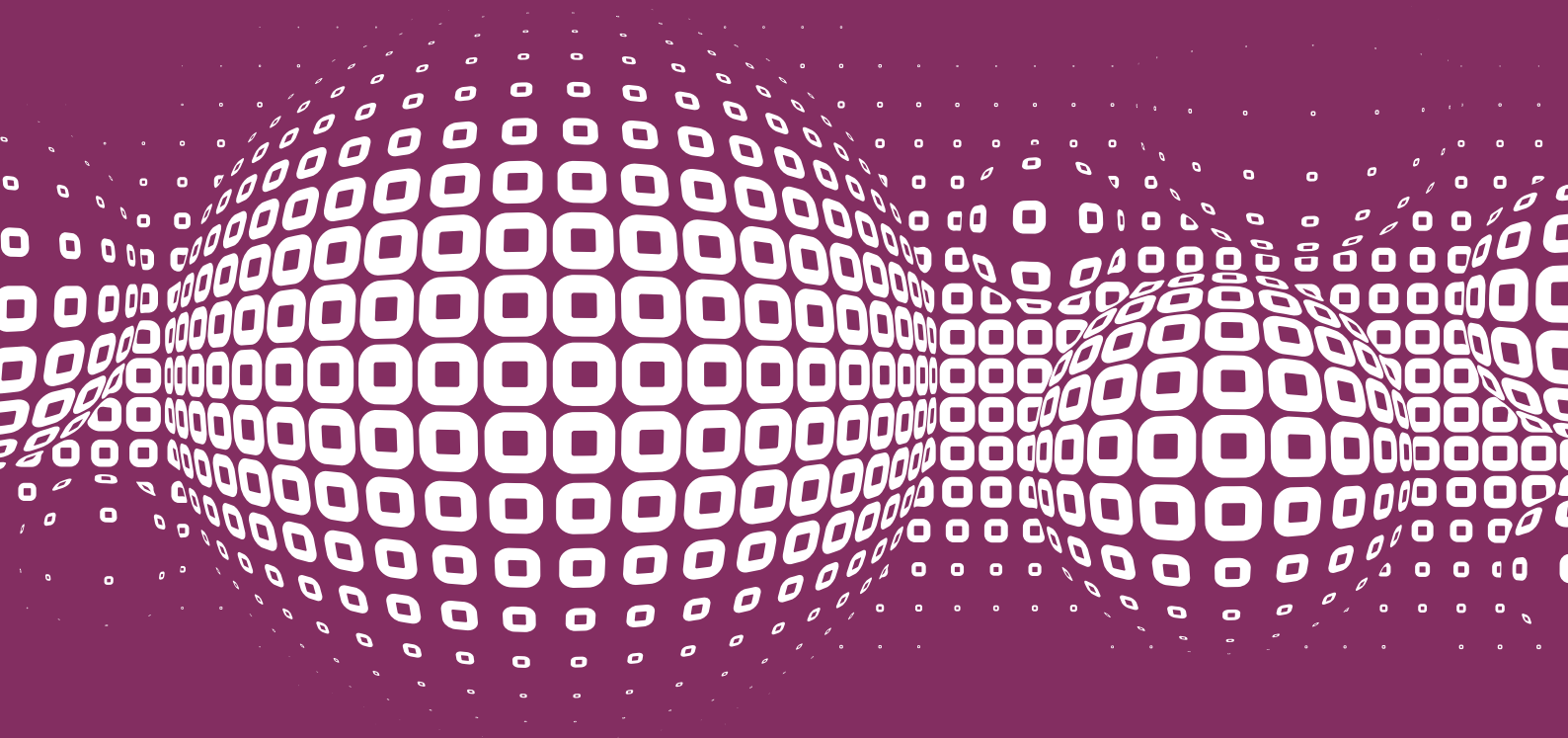
## Glossary

| | |
|---|---|
| AHRC | Arts and Humanities Research Council |
| BBSRC | Biotechnology and Biological Sciences Research Council |
| BIS | Department for Business, Innovation and Skills |
| CCLRC | Council for the Central Laboratory of the Research Councils |
| DECC | Department of Energy and Climate Change |
| DEFRA | Department for Environment, Food and Rural Affairs |
| DfT | Department for Transport |
| DoH | Department of Health |
| DTI | Department of Trade and Industry |
| DSTL | Defence Science and Technology Laboratory |
| EPS | Engineering and Physical Sciences |
| EPSRC | Engineering and Physical Sciences Research Council |
| ESRC | Economic and Social Research Council |
| HEFCE | Higher Education Funding Council for England |
| HEI | Higher Education Institute |
| HESA | Higher Education Statistics Agency |
| IKC | Innovation and Knowledge Centre |
| IMRC | Innovative Manufacturing Research Centre |
| IRC | Interdisciplinary Research Collaborations |
| JIF | Joint Infrastructure Fund |
| JISC | Joint Information Systems Committee |
| KE | Knowledge Exchange |
| KTA | Knowledge Transfer Account |
| KTS | Knowledge Transfer Secondment |
| MoD | Ministry of Defence |
| MRC | Medical Research Council |
| NERC | Natural Environment Research Council |
| NI | Northern Ireland |
| PPARC | Particle Physics and Astronomy Research Council |
| QMUL | Queen Mary University London |
| QUB | Queen's University Belfast |
| RCB | Robertson Centre for Biostatistics |
| RCUK | Research Councils UK |
| RAEng | Royal Academy of Engineering |
| REF | Research Excellence Framework |
| SFC | Scottish Funding Council |
| STFC | Science and Technology Facilities Council |
| TSB | Technology Strategy Board |
| UoA | Units of Assessment |
| WOSCOPS | West of Scotland Coronary Prevention Study |



EPSRC

Investing in research for discovery and innovation



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