August 2020

Value of EPSRC Fellowships

Stage 2 Final Report

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Executive summary

EPSRC Fellowships are aimed at nurturing aspiring and established research leaders by providing them the support, flexibility and freedom to develop their research ideas. Grants are awarded to individuals with the greatest potential (rather than projects) at early and established career stages. In addition, targeted fellowship schemes are launched periodically to build critical mass and/or capabilities in areas of strategic priority.

The expectation is that fellows will deliver the highest quality research, make significant contributions to their field, improve their visibility (in their field and internationally), and progress in their career – for instance, postdoctoral fellows establishing their own research group. **603 fellowships have been funded since 2006**. These fall into three 'groups'.

- Traditional early career fellowships, consisting of the postdoctoral, Career Acceleration and Early Career Fellowship schemes
- Traditional fellowships for established researchers, consisting of the Senior, Leadership and Established Career Fellowship schemes
- 'Targeted' fellowship programmes, including Challenging Engineering, Manufacturing and Engineering for Growth Fellowship schemes

The University of Oxford, Imperial College London and University of Cambridge account jointly for 224 or more than 37% of all awarded fellowships while the remaining 379 fellowships are divided among 44 different organisations.

The independent research consultancy, Technopolis, in partnership with Vitae and Science-Metrics was commissioned by EPSRC to assess the added value, the economic and wider impact of EPSRC fellowships funded since 2006. A mixed-methods approach consisting of economic modelling, primary data analysis (survey and interviews with fellows and alumni) and secondary data analysis (e.g. of bibliometrics/citation data, ResearchFish data) underpinned the impact assessment, the findings of which are described in the following sections.

The EPSRC Fellowships unlock a series of immediate benefits for fellows

Different conditions apply to different fellowships, but broadly speaking they offer fellows a bursary to conduct their research, set up a research group, visit potential international partners, for 3-5 years. It also facilitates access to training, mentoring, and research facilities.

There is an almost universal agreement among fellows that the **main immediate benefit of taking part in an EPSRC fellowship is the opportunity to focus on their research** due to the lack (or reduction) of other obligations, including teaching and administrative duties, in comparison with their peers. The fellowship also provides them the **freedom and independence** to explore their own ideas, and change direction to follow new research paths. Time and money also allow them to explore '**riskier' research paths** and engage in collaborations with academics in the same field, multidisciplinary teams and industry. There are also positive reputational effects of receiving what is considered a prestigious award.

Almost all fellows would recommend their EPSRC fellowship to others, and even with the benefit of hindsight, they state that they would still prefer the EPSRC fellowship over a grant.

> *"The fellowship enabled me to dedicate large chunks of time to thinking about 'hard, adventurous, long-term problems'…" (Senior fellowship, 2007)*

"It allowed me to think about some really high risk projects … whereas I don't know if I would've done that if I wasn't on the Fellowship… if you don't have much time to do research you want to focus on things that will definitely produce research outputs." (Postdoctoral Fellowship, 2017)

"The Fellowship proved to be great for allowing me to try out high risk things in interdisciplinary work, because if something didn't work out, I had flexibility to move funds elsewhere. Work on grant funding wouldn't have been anywhere near as boundary pushing as I was able to do with the Fellowship." (Challenging engineering fellowship, 2008)

These initial benefits, combined, translate into further benefits in terms of scientific production, career progression and opportunities to collaborate

In total, EPSRC Fellowships have led to the publication of 11,775 research papers. On average, the most number of publications were from Leadership (35.5 papers), Established Career (31.1 papers) and Engineering for Growth fellows (30.6 papers), while Pre- and post-2011 Postdoctoral fellows (6 and 10 respectively) had the least. **The Average Relative Citation (ARC) score of papers published by EPSRC fellows is 2.06,[1] which means that these are cited two times more frequently compared to the world level (i.e. 1.0).** This is in line with similar impact measures for the EPSRC as a whole (e.g. 2.06 in Field-Weighted Citation Impact[2]). However, 25% of the top 10% Highly Cited Publications (HCP 10%), in their respective fields, come from EPSRC fellows.

About a **half of the 603 fellowships reported collaborations with partners** in the UK (46% of collaborations) and across the globe including Europe (27% of collaborations), according to ResearchFish. In addition, both academic and industrial partners were engaged (44% and 36% of collaborations respectively), with industrial collaborations more prevalent among targeted fellowships.

This leads to a virtual circle that enables, among other things, further access to funding, with an estimated £43.4m leveraged from collaborators and £809.1m further investment captured by EPSRC fellowship alumni according to ResearchFish.

With regard to career development, **93% agreed that the fellowship had made a significant difference to their career path.** 86% of respondents agreed that it had impacted on the level of seniority they had reached, with similar proportions agreeing they had experienced faster career progression than they would have done without a fellowship.

As expected, different schemes have different effects. Targeted fellowships are more likely to lead to increased research impact and improved collaboration abilities, while unsurprisingly fellowships to established researchers are less likely to influence career progression and research independence (as reported by survey respondents). Fellows have an accelerated career trajectory (as confirmed in the survey and interviews), with early career researchers in particular agreeing that it was easier to secure a permanent position after their fellowship.

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[1] 8,104 papers have a valid RC (Relative Citation): publication sets from which citation-based bibliometric indicators are computed. Only papers published in 2017 or earlier have an RC score.

[2] https://epsrc.ukri.org/newsevents/pubs/publicationsanalysis/

"The Fellowship gave my career a strong push: during it I received two promotions. When I applied for the Fellowship I was a Senior Lecturer; the year after I became a Reader. In 2016 I was promoted to a Chair. It was a large Fellowship and the way I used it 'ticked' all the criteria needed for promotion: international reputation, publication of papers, and so forth." (Early Career fellowship, 2013)

Scientific knowledge and its dissemination as well as the training of the future generation of researchers enables wider social and economic impact

Fellows have contributed to the training of the next generation of researchers, supervising doctoral researchers, managing other researchers and leading a research group, and reviewing and managing staff performance during their fellowship.

Additionally, there are a series of innovation outcomes emerging from the fellowships, including the creation of spin outs (and the new jobs associated with them) and new inventions associated to fellows, as well as and further knowledge flows that also materialised in new inventions in the wider society.

To date, **50 EPSRC fellowships from 2006-2016 contributed to the creation/development of spinouts,** which have also received further contribution from other EPSRC grants. On average 3.6 spinouts were launched per year.

EPSRC fellows/alumni have also developed new inventions, and this can be approximated by looking at their patent applications and other intellectual property (IP) protection. **106 patent applications are linked to the EPSRC Fellowships and 35 patents have been granted to date.**

There are also 234 examples of the development of research materials, tools and methods during the EPSRC fellowships. Of these, 185 entries related to the development of software, 23 entries relate to the development of a webtool application, and 14 relate to the development of a new/improved technique or technology. For example, GraphicsFuzz, an automated testing tool for graphics drivers, developed through an Early Career Fellowship led to the formation of a spinout company, was subsequently bought by Google.

Furthermore, EPSRC fellows' scientific research has contributed to the development of new technologies developed by other researchers/innovators. They have co-authored papers with industry, and their scientific production has been used in the development of further knowledge and innovation. 42% (4,964 of 11,775) of papers attributed to EPSRC fellowships are cited by the private sector, and **414 of all publications associated to fellows are referenced in 1,012 patents filed by others,** according to data from Researchfish and 'Lens' (a repository of bibliometric and patent data).

There is also evidence of wider uptake by academics, industry and policymakers. The majority (59%) of survey respondents suggest that their research has been used, at least to some extent, by industry and business and 22% suggest it has been used, at least to some extent, by policymakers. Advocacy activities are also resulting in longer term impact in the research, economic and regulatory domains.

Finally, research from EPSRC fellowships is contributing towards health, social and environmental impacts. For instance, research has contributed to the development of new imaging methods that have been taken up by MRI scanner vendors and to the development of imaging techniques for neurology and cancer diagnosis and monitoring. Research has also helped secure the supply of safe drinking water from ageing infrastructure and contributed to new industrial collaborations on solar energy. One Early Career Fellowship recipient "*worked* *with Electricity North West to deliver a decision making tool which to date has saved £5 million for customers*". This work has been picked up by the National Grid as best practice. One former postdoctoral fellow indicated that his work on uncertainty quantification for climate modelling is used regularly for policy analysis at the European Commission and is expected to be used by the UK government.

An economic assessment of the benefits (only taking into account benefits that can be monetised) reveal a net benefit of £615.2m emerging from the fellowships

A sub-set of the benefits described above can be monetised to derive an estimate of the benefits of EPSRC fellowships, in monetary terms.

- Approximately **£43.4m** has been **leveraged** from collaborators and **£809.1m further investment** has been attracted by EPSRC fellowship alumni, as mentioned above
- Fellowship alumni are anticipated to benefit from a **wage premium**, over the remainder of their career, which is estimated at a total of **£8.3m** to be accrued over a period of 31 years
- The total additional net present value of the spinouts created by (or associated to) fellows amounts to **£317.5m.** This turnover is assumed to be accrued over a period of 50 years. These spinouts are associated with the creation of **57-142 jobs**
- The granted patents attributable to the EPSRC Fellowships have a combined value of **£24.8m**, when assumed to be accrued over a period of 20 years
- The patents that cite publications attributed to EPSRC fellowships have an estimated **additional value of £477.5m,** when assumed to be accrued over a period of 20 years.

The total estimated benefits of the portfolio of fellowships funded, after adjusting for displacement, substitutions and deadweight, amount to **£615.2m under conservative assumptions.** The estimated benefits reflect the value of EPSRC investment with adjustments made for co-funding. The total costs of the fellowships equal £442.5m, assuming they comprise the total grant value of the fellowships (just over £399m) plus the partners' contributions (£43.4m). **Consequently, the estimated return on investment (ROI) of the EPSRC Fellowship Programme is 1.39. For every £1 invested in EPSRC Fellowships there is an additional benefit of £0.39.** This is a positive result and most likely an underestimation of the impact of the fellowships as it only captures the impact that is monetised through the four channels of impact indicated above.

The EPSRC fellowships offer more support and are designed to increase the likelihood of impact in comparison with other schemes

We compared EPSRC fellowships to the Royal Society's University Research Fellowships and Newton Advanced Fellowships (co-funded with AMS), the EC's Marie Skłodowska-Curie Actions, Royal Academy of Engineering's Industrial Fellowships, UKRI's Future Leaders Fellowships and Leverhulme Trust's Major Research Fellowships. The chosen comparator schemes cover the range of EPSRC fellowships in this study. The main differences for EPSRC fellowships include

- Clear aims linked both to supporting researcher careers and to contributing to the wider global body of knowledge. The latter is less explicit in comparator schemes.
- Expectation to have socioeconomic impacts, which is mirrored only in the Marie Skłodowska-Curie individual fellowships and UKRI Future Leaders Fellowships
- No eligibility rules based on years of post-doctoral experience, while the comparator schemes stipulate years of experience
- Costs of most research and developmental activities are covered, including travel, training and visiting researchers. Others do not always cover all these activities; however, some

schemes offer clear training budgets and a formal mentoring programme (RAEng Industry Fellowships).

The duration, amount of funding, flexibility and prestige of EPSRC fellowships make them attractive to researchers, with 96%, 94%, 87% and 77% of survey respondents respectively identifying these features as important. Overall, the fellows were satisfied with administrative processes, but felt that support from the host organisation and mentoring could be improved (as per the survey and interviews).

1 Introduction

1.1 This report

Technopolis in partnership with Vitae and Science-Metrics has been commissioned by the EPSRC to evidence the added value, the economic and wider impact of their fellowships funded since 2006. This report explores how investing in an individual, their career advancement and scientific research programme (impact on fellow's career, UK capability and capacity, research area) adds value.

The analysis draws on quantitative and qualitative data to provide a full picture of wider benefits. The remainder of this chapter provides an overview of the EPSRC Fellowships and our methodological approach.

- **Section 2** provides a brief description of the EPSRC Fellowships and their key features
- **Section 3** presents an assessment of the direct benefits enjoyed by fellows due to participation in the fellowships (intermediate impact), including collaborations, scientific production and career progression and leverage of further investment.
- **Section 4** presents the benefits emerging from the fellowships (impact) in terms of skills and capabilities (training others), innovation (including spill overs) and wider impact.
- **Section 5** provides an economic assessment of impact, including an estimation of return on investment
- **Section 6** provides a comparison with other schemes
- **Section 7** concludes the report and provides a series of recommendations

1.2 Methodological approach

The wider approach to methodology combines theory-based evaluation principles with classic economic techniques, within the limits of what is possible given the methodological challenges. The analysis builds on a review of secondary data and consultation with EPSRC alumni (i.e. former EPSRC fellows). Figure 1 provides an overview of the proposed approach and methodologies. A range of methodologies and approaches to data collection feed into the analysis of impact dimensions.

Figure 1 Overview of approach and methodology

METHODOLOGY	Economic modelling including patent analysis	Analysis of Research Fish data	Bibliometrics/ citation analysis	Survey of fellows/alumni	Interviews with fellows/alumni
Impact on fellow's career and UK capability and capacity		√		√	√
Impact on research & innovation		√	√	√	√
Economic impact	√	√	√		
Wider impact		√		√	√

The economic modelling draws on data for monitoring 603 completed fellowships and Researchfish data. The Researchfish data includes data on spinouts, entries on intellectual property protection, including granted patents, and EPSRC fellowship publications that are referenced by patents. The economic value of the grants data and outputs (spinouts, patents, publications) are assessed and a monetary value is placed on each of the estimated outcomes/impacts. The total assumed benefit of the programme is compared with the cost of investment in a return on investment analysis.

The grants data and Researchfish data are analysed by fellowship type to enable the assessing of the relative strength of the different types of fellowships funded. A bibliometric analysis is conducted, drawing on the portfolio of EPSRC fellowships. Publications are identified through Researchfish. Data from 529 of 603 EPSRC fellows is taken from Researchfish and data for 528 fellows can be matched to Scopus. An overview of the documents retrieved in Scopus is presented in the Appendix B.3, by document type. Note that the production of bibliometric indicators is limited to articles, reviews and conference papers (and some book chapters). Data for an additional 18 fellows is identified through a tracing of funding acknowledgements. In total, data for 546 of 603 (90%) fellows is identified. In total, 11,449 papers are matched to Scopus and an additional 910 paper are identified in Scopus funding acknowledgements, and thereby, a total of 12,359 papers are subject to the bibliometric analysis.

A survey of EPSRC Fellowship alumni was used to explore their views of their fellowship. The alumni were asked about their experiences during their fellowship, what had worked well, what could have worked better and the impact it had on their career. They were asked specifically about applying for their fellowship, the training and mentoring opportunities that they had and the support from their host institution. It also explored the impact of their fellowship in terms of the research outcomes, the extent to which their outcomes had been used by others, whether there had been any unexpected outcomes from their research and any wider impacts. In total 223 responses are collected. The profile of respondents is given in Appendix B.4 and a selection of quotes is provided in Appendix D.

A semi-structured interview programme with 23 alumni is conducted to explore personal career impact, including leadership capability; research outputs; economic impact; wider impact; and unexpected impacts. The sample of interviewees is drawn from the data provided by EPSRC and informed by the responses to the survey, and specifically designed to include participants from all the programmes, across the disciplinary themes and covering a range of characteristics, as appropriate (e.g. gender, career stage, time since fellowship, etc.).

2 EPSRC Fellowships

2.1 Overview of the fellowships

603 EPSRC fellowships have been funded / completed since 2006. The application for these fellowships were submitted by researchers from 47 universities across the UK (see Appendix A). The highest number of fellowships were affiliated to the University of Oxford, followed by the Imperial College London and the University of Cambridge. Those three organisations combined account for 224 or more than 37% of all awarded fellowships while the remaining 379 fellowships are divided among 44 organisations (see Appendix A).

Funders use fellowship programmes to increase national/disciplinary research capacity, to support the knowledge economy and to prepare the 'next generation' of researchers. Fellowships from the UKRI councils and UK national academies are considered to be the most prestigious types of grants for UK (and international) researchers. In this way, they are often used as tools to promote international cooperation between governments and enhance 'soft power' (e.g. as in the Newton Fund).

Fellowships come in diverse forms but at their core aim to produce excellent research and to promote career progression / international standing for individual researchers over and above what is expected from the majority of the research community. However, fellowships have also evolved with international trends in R&I, such as the rise of the impact agenda (e.g. REF), a need to work in an interdisciplinary way, thematic changes (AI, quantum technologies), and challenge-led research (e.g. addressing the industrial strategy). New forms of fellowships have been developed to address these changes, such as international exchanges (Royal Academy of Engineering's visiting professors and visiting teaching fellows programme), tackling of development challenges (Royal Society and AMS Newton Advanced Fellowships) and industry transitions (Roche Postdoctoral Fellowships).

The expectation is that many fellows should have produced R&I products by the end of their award and have disseminated these with experts in their field. For established fellows, their research should have had a significant impact on the field/industry and as well as wider impacts, such as policy influence. They should have progressed in their career relative to their position at the beginning of the award, whether that be leading their own research group or becoming internationally renowned. Fellows also serve as examples to more junior researchers as fellows are required to mentor colleagues as part of their award. Table 1 shows a basic summary of EPSRC fellowships. Based upon the six characteristics in the table, there are three 'groups' of three fellowship programmes: traditional early career fellowships, traditional fellowships for established researchers, and 'targeted' fellowship programmes. The intended impact (long-term) of all fellowships is for the fellows to have contributed to national strategic needs (e.g. future economic success).

Table 1 EPSRC fellowships summary

	EPSRC Fellowship Scheme	**Number completed**	**Research impact**	**Emerging**	**Established**	**Wider impact/influence**	**Theme specific**	**Team building**

Early career fellowships	Post-doctoral (Pre 2011)	158	√	√				
	Post-doctoral (Post 2011)	53	√	√				
	Career Acceleration (superseded by early career in 2011)	107	√	√				
	Early Career	105	√	√				√
Fellowships for established researchers	Senior (superseded by Leadership in 2007)	18	√		√			√
	Leadership (superseded by established career in 2011)	69	√		√			√
	Established Career	43	√		√	√		√
Targeted fellowships	Challenging Engineering	37	√	√			√	√
	Manufacturing	3	√	√	√	√	√	
	Engineering for Growth	10	√	√	√	√	√	√
	Total	603						

2.2 Key features and EPSRC support

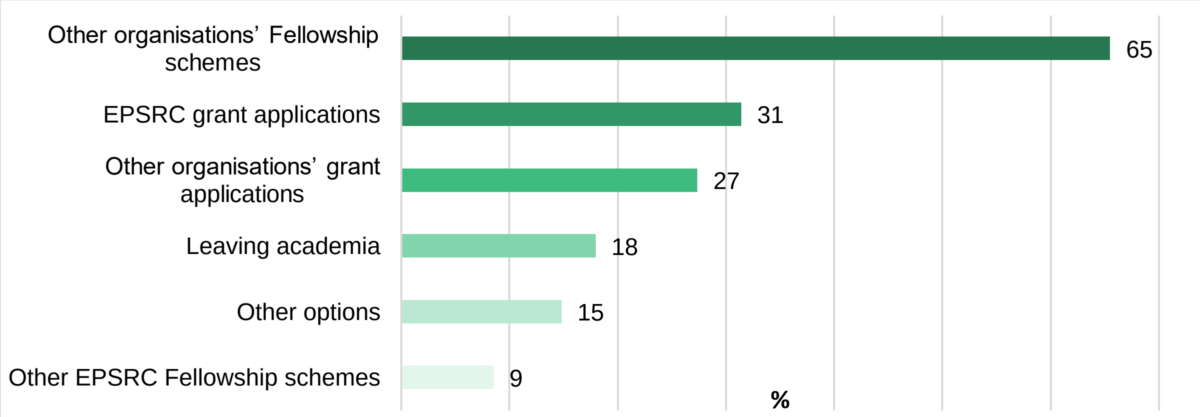
2.2.1 Motivation for applying

The majority of respondents (65%) considered other fellowship schemes at the time of their application to EPSRC, with applying for EPSRC grants the next most common activity (see Figure 2). Around a third had considered grant applications (either from EPSRC or other institutions), but -in a separate question- only 5% declared that, in hindsight, they would have rather applied for EPSRC project funding through a grant. This indicates (at least indirectly) that fellowships do provide more value to fellows than individual grants.

Early career fellowship respondents were least likely to have considered applying for other EPSRC fellowships or grant applications (5% and 20%, respectively), while 72% had considered other organisations' fellowship schemes. 40% of targeted fellowships respondents had considered grant applications to other organisations.

There were no gender differences in the proportions of respondents who had considered other organisations' fellowship schemes or considered leaving academia. However, male respondents were consistently more likely to have considered a range of other options alongside their EPSRC fellowship application.

Figure 2 Other options considered at the time of application (%, N=223)



In terms of the features of the EPSRC fellowships that motivated their applications, most widespread important motivations related to the time, space and capacity to exploring interesting things. The prestige associated with a fellowship (from EPSRC) was also important for many.

In fact, the duration of the fellowship was identified as the most important feature overall in our survey with fellows (67%, 143 of 213 indicate this as 'very important'), followed by the amount of funding and the flexibility of the fellowship conditions (see Figure 3).

As further explained by fellows via comments in the survey, the flexible nature of the funding allows them to respond to new findings and research directions during the course of the award. This flexibility also translates into the ability to transfer the funding from institution to institution; effectively allowing the holder to leverage the funding when searching for a permanent academic post. This is further illustrated in the testimonial provided in the table below.

Other features were mentioned by 26 respondents including the ability to focus on a major project (7); the opportunity to remove or reduce their teaching load (6); having access to studentships (2); building up their research group (2); opportunity to work closely with user groups, communities and stakeholders (2).

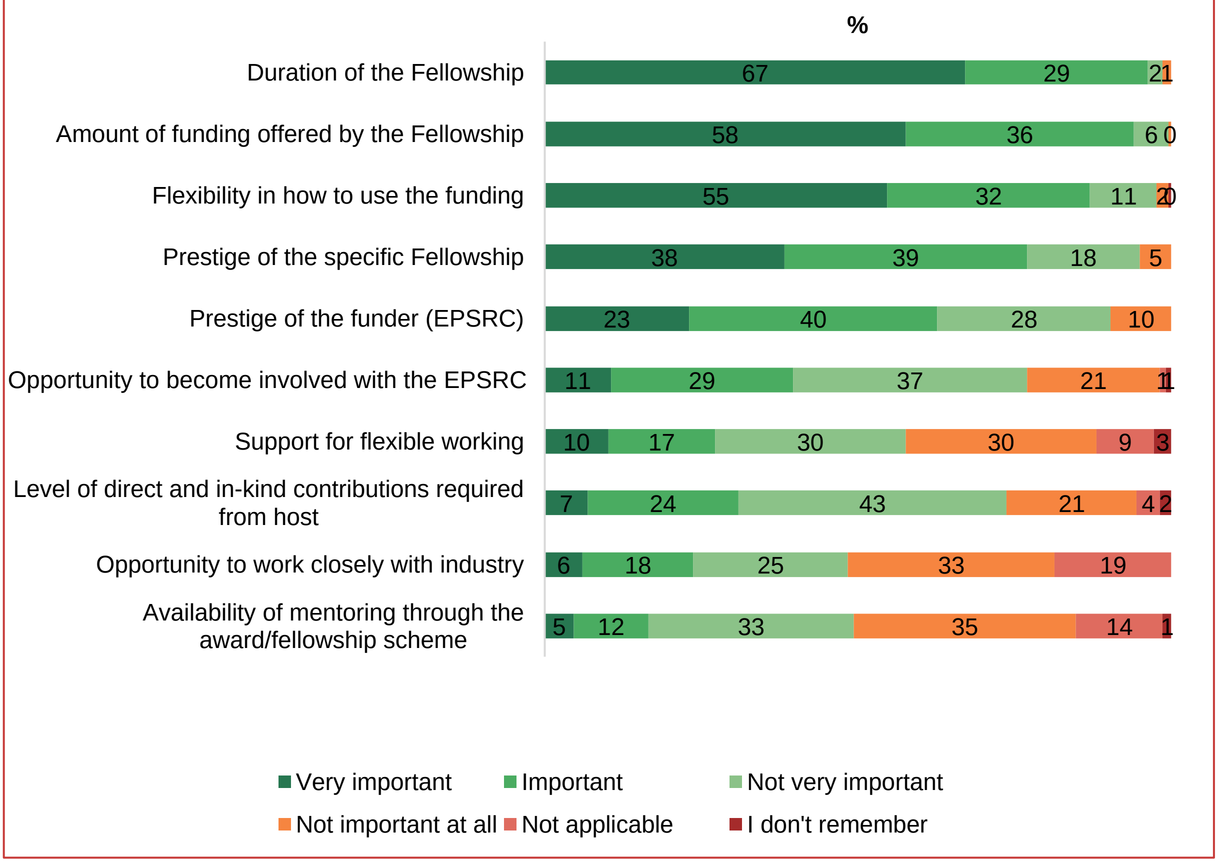
Four respondents reported the opportunity for a change in career direction or progression, including a route into academia (2), returning to the UK and returning to research.

Female respondents were generally more likely to identify the features of their fellowship as 'very important' than male respondents, across all categories presented in the figure below. This was most apparent in the prestige of the fellowship (48%F: 35%M), amount of funding (66%F: 55%M) and the flexibility in the use of the funding (61%F: 52%M).

Table 2 Evidence from interview – Leadership fellow

2009 (Nottingham), now Professor of Polymer Therapeutics, University of Nottingham
A significant attraction of the five-year Leadership Fellowship was the length of time it gave and the flexibility:
"With the Fellowship you can follow interesting ideas and give flexibility to your team… to follow up interesting [unexpected] experimental results… instead of people having very specific goals to get results quite quickly".
"to think a bit more about the translational landscape for polymer materials: this Fellowship allowed me the distance to be able to look at these questions in the round and not have to bend the research question to meet very defined objectives [as in a pre-defined 'challenge-led' grant] …Having a team that was a bit more stable was fantastic… the development time for true translation in the biomedical world really is long."

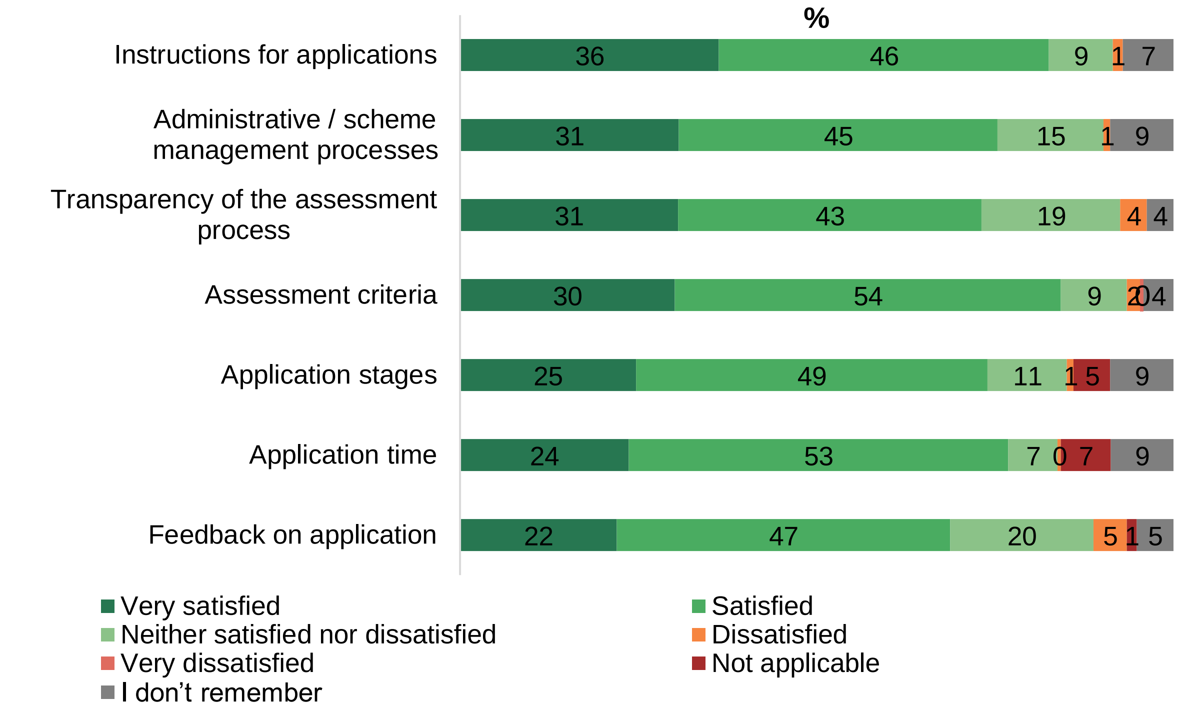
Figure 3 Important features of fellowship (%, N=218)



2.2.2 Application process

We asked about levels of satisfaction with various aspects of the application process via survey. **In all cases the vast majority were satisfied or very satisfied with the seven aspects of the application put forward to them (from instructions to transparency, assessment criteria, timing and feedback)** (see Figure 4). There were few differences per type of fellowship or gender.

Figure 4 Administrative processes (%, N=216)



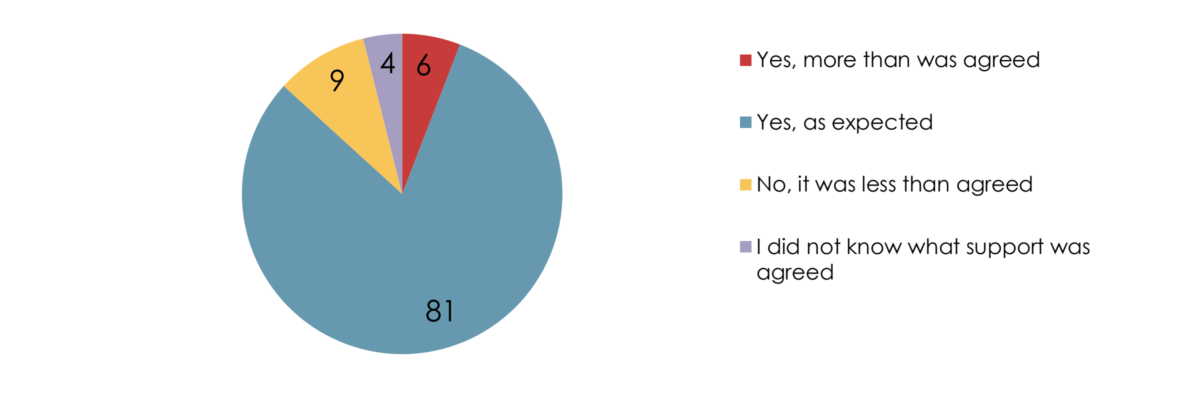
2.2.3 Support from host organisation

When asked about whether host support matched what was agreed and the vast majority (81%) said it had, with an additional 6% indicating it exceed expectations. Early career fellows were slightly less likely to agree than established researchers, and this perhaps reflect the need for more support in early stages. There were few differences per gender.

In the instances in which the host organisation had exceed expectations (6%), respondents cited examples of finding funding for additional studentships or postdoctoral researchers (4), providing access to facilities (2) being responsive and encouraging (2) and lowering teaching responsibilities in response to more departmental responsibilities (1).

On other hand, in the instances where fellows received less support than outlined in the Host Agreement Statement (9%), respondents cited being required or pressurised to do more teaching than expected or to be heavily involved in departmental activities that would have reduced the time to do research (7); less access to facilities than expected (6); not receiving the studentships that they had expected (4); lack of support at the end of their fellowship (3).

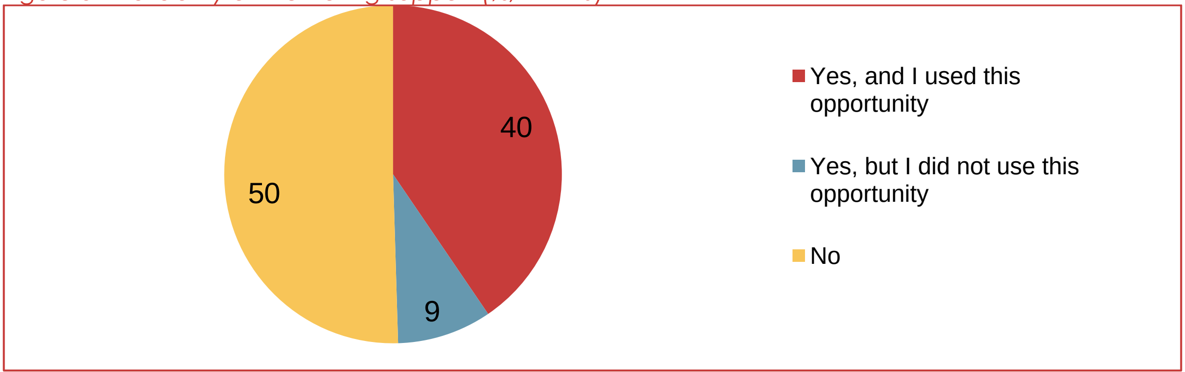
Figure 5 Level of support from host organisation (%, N=205)



2.2.4 Mentoring

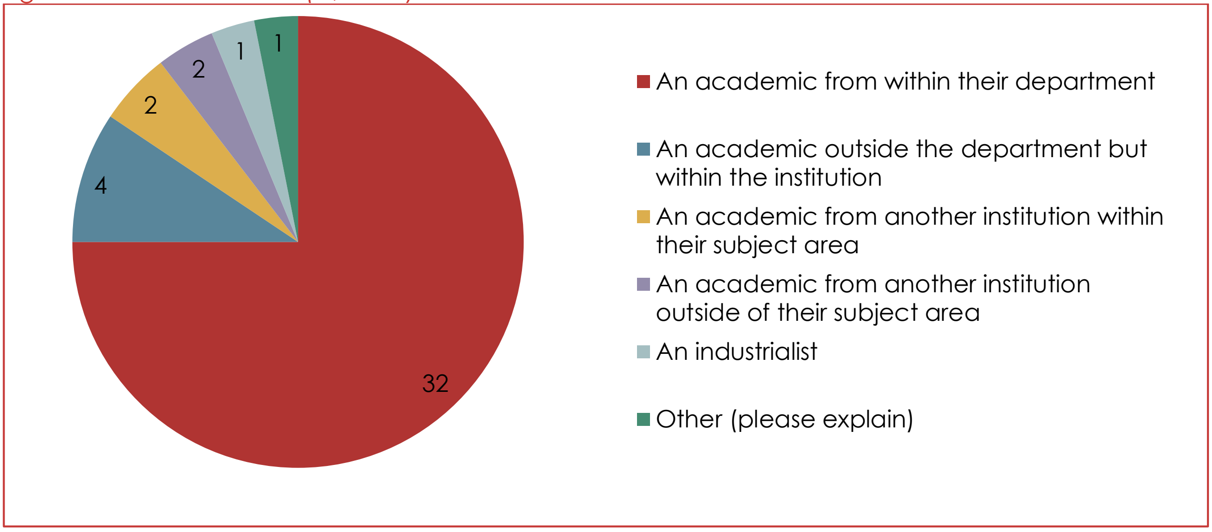
Half of respondents had access to a mentoring scheme as part of their fellowship, with 40% of all respondents using this opportunity. 34% of female respondents had participated in mentoring, with 55% not having the opportunity to do so. Early career respondents were most likely to have had this opportunity (56%) and use it (49%). Half of targeted fellowship respondents were offered a mentor with only 30% taking up this opportunity. Perhaps unsurprisingly, established respondents were least likely to be offered the opportunity (34%) and to have taken it up (22%).

Figure 6 Availability of mentoring support (%, N=210)



Overwhelmingly, mentors were from within respondents' departments (84%), with another 10% coming from somewhere else within their institution. Only three respondents reported having a mentor from industry.

Figure 7 Profile of mentors (%, N=86)

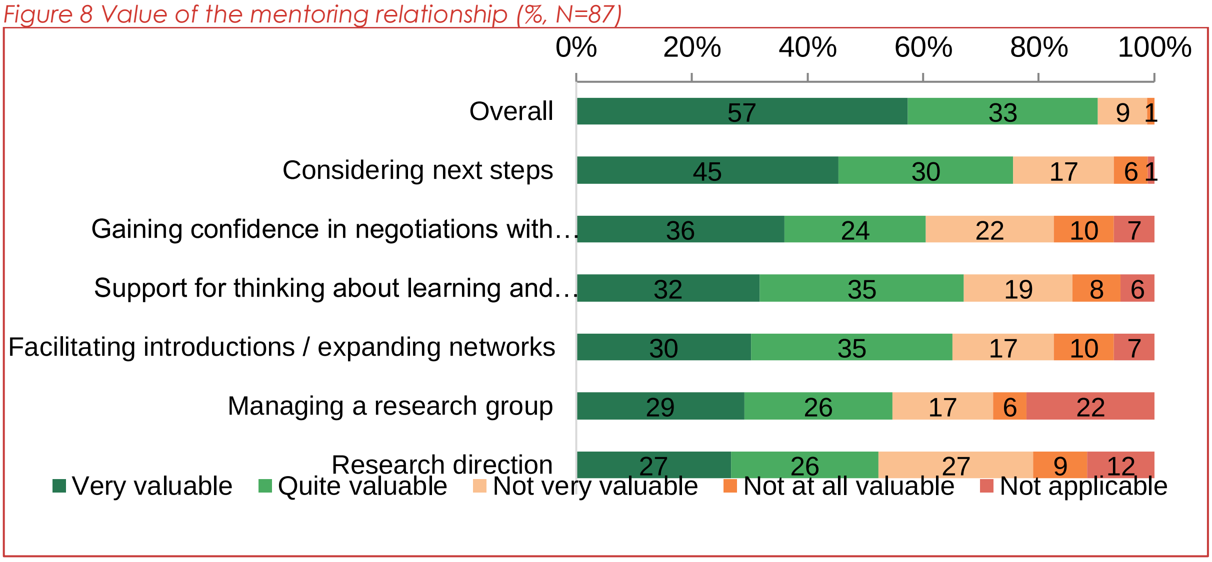


90% of respondents reported that their mentoring relationship had been valuable overall, with 75% identifying its value in considering the next steps in their career and 53% in supporting the direction of their research. A third of targeted fellowship respondents did not see their mentoring relationship applicable to their research direction.

As it would be expected, early career respondents were most likely to see their mentoring relationship as very valuable (66%), while less than a third of other respondents reported this. In comparison with other respondents, early career respondents were also more likely to see their mentoring relationship as very valuable in considering their next steps (49%) and gaining confidence in negotiations with their department (40%).

Female respondents were more likely than male respondents to find their mentoring relationship very valuable overall (69%) and in supporting their next career step (50%) and thinking about their learning and development (44%). While male respondents were more likely to find their mentoring relationship very valuable for gaining confidence in negotiations with their department (39%), expanding their networks (31%) and the direction of their research (29%) compared to female respondents.

Figure 8 Value of the mentoring relationship (%, N=87)

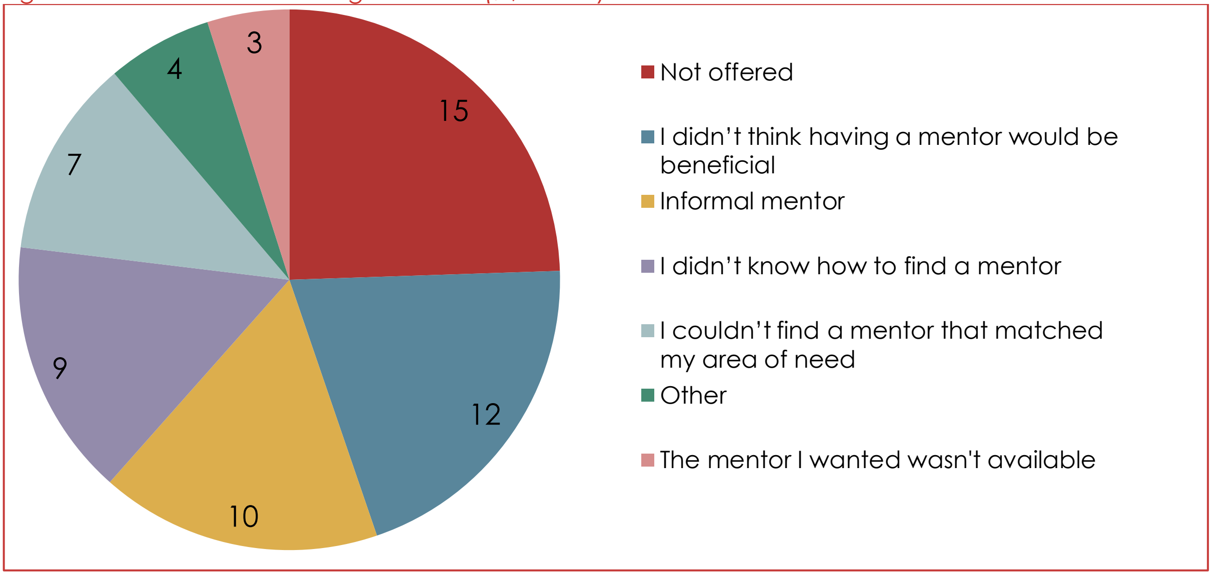


For those respondents who didn't have a mentor during their fellowship 12% reported that they didn't think a mentor would be beneficial, 10% using informal 'mentors' and 9% didn't know how to find a mentor. Of the 15% not offered a mentor, a few established fellowship respondents noted that mentors were not seen as appropriate for senior academics and perhaps a different approach or terminology would be more effective. Other respondents noted that a more informal relationship with a variety of people was more beneficial.

"I was perceived to be too senior for a mentor. Might be better to rename for senior people, e.g. "buddy" in a different department, as the skills you need later in life are different to that required by ECRs."
Established Career Fellow

"I don't see the value of a single mentor: my preference is to approach people if I need input, and I am quite happy to do so. I did have a mentor before my fellowship, who helped me develop these skills."
Leadership Fellow

Figure 9 Reasons for not having a mentor (%, N=117)



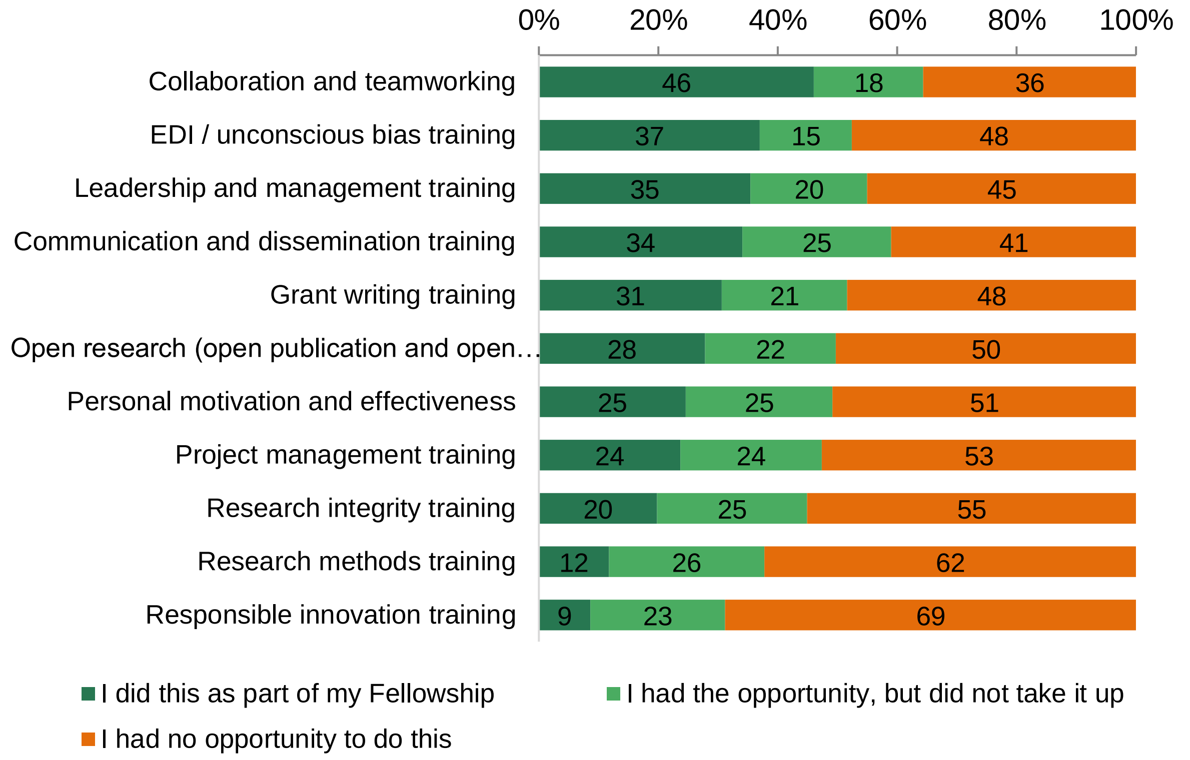
2.2.5 *Training and other development opportunities for fellows*

Around a half of all respondents had access to or participated in a wide range of training courses covering many standard topics, but also more specialised training such as EDI-related training and open research. They were least likely to have access to training on responsible innovation and research methods.

The responses were fairly consistent across the fellowship groups, with early career respondents more likely to participate in research methods training (15%), targeted fellowship respondents more likely to participate in leadership and management training (55%) and established career respondents less likely to participate in grant writing training.

Female respondents were more likely than male respondents to have participated in training, particularly collaboration and teamworking (59%), personal motivation and effectiveness (38%) and project management (37%). Conversely, female respondents were least likely to have participated in research methods training (15%) and research methods (8%) and more likely to report that these training opportunities were not available. No female respondents had participated in responsible innovation training.

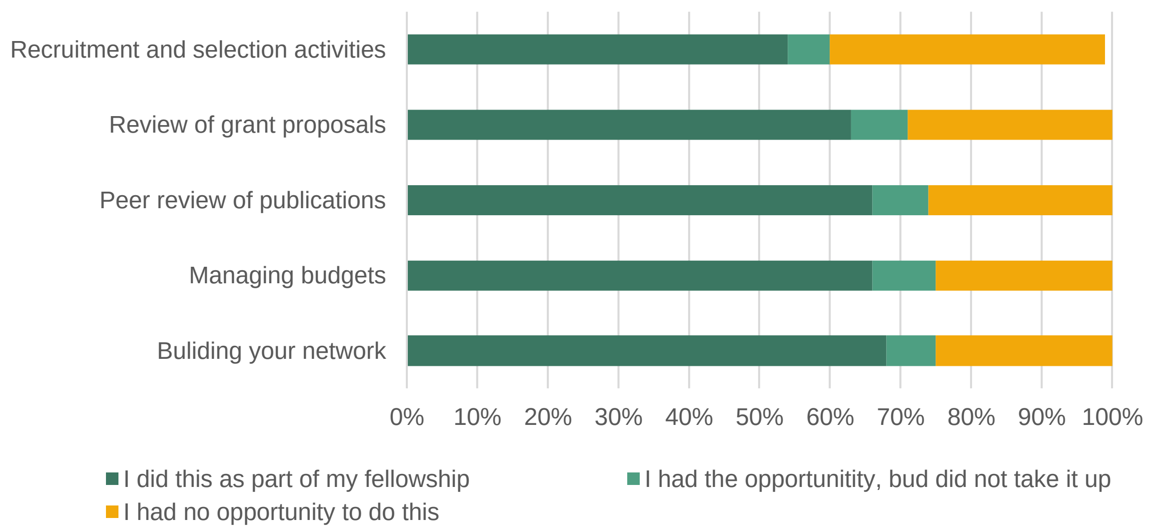
Figure 10 Participation and availability of training opportunities (%, N=192)



Around two thirds of all respondents participated in a range of development opportunities, including building their networks (68%) and managing budgets (66%). 60% had experience supervising doctoral researchers, and 58% managing other researchers and leading a research group, while 44% were involved in reviewing and managing staff performance during their fellowship.

Targeted fellowship respondents were most likely to have participated in these activities overall, particularly in recruitment and selection activities (67%), reflecting the stage in their careers. Early career respondents were least likely to have been involved in reviewing and managing staff performance (34%) and to report that they didn't have an opportunity to do this. Slightly more than half of early career respondents lead a research group (54%), supervision of doctoral researchers (56%) and recruitment and selection activities (51%). They were also slightly more likely to have peer-reviewed papers (68%) as a result of their fellowship.

Figure 11 Participation in development opportunities (%, N=189)



Of the few respondents who suggested other training and development opportunities would have been valuable, the majority identified preparing for the next step after the fellowship. This included preparing applications for permanent positions, applying for grants and supporting group members. Other suggestions included managing their research group, reviewing grant proposals and engagement with policymakers and the media.

"How to secure lectureships, training in dealing with the informal offers environment that comes with potentially transferring fellowships to secure a permanent position."
Postdoctoral Fellow (post 2011)

"In retrospect, it would have been useful to have planned for the end of the project in more detail, especially with respect to contract extensions and the movement of staff to other employment (whilst still working on papers from the Fellowship). I expect there are some training courses that would be relevant to that in some way."
Early Career Fellow

2.2.6 *Areas of satisfaction (what worked well)*

Many areas covered in the subsections above show high levels of satisfaction with various aspects of the fellowships (including the administrative process, support from host organisation and mentoring), which were directly enquired about in the survey.

We also asked respondents to comment (via open text) on features of the fellowships that worked well. Main things highlighted (by 164 respondents) include:

- The **flexibility of conditions** (working conditions, use of funding, flexibility on research activity) (66%), in line with the key feature highlighted above. A few specifically commented on the Equity, Diversity and Inclusion (EDI) aspects of this flexibility, mentioning maternity leave, shared parental leave and accommodation of medical conditions.
- **Access to funding**, including the fellowship and access to further funding (25%), which not only allowed them to advance their research agendas but in some cases also to be able to build their research group, or connect with international partners.
- **Time for research** due to a lack of other obligations, and more specifically, not having to teach (20%). Furthermore, in a separate question, 91% of 214 total respondents stated that they agreed or strongly agreed that they were able to commit (almost) all of their time to research compared to their peers as a result of their fellowship. Box 1 below expands further on the issue of teaching load.

- **Freedom and independence** to explore their own ideas and change direction to follow new research paths (16%)
- **Opportunities to visit / attend other institutions and conferences** (16%), which in turn also contributes to setting up fruitful collaborations (see Section 3.2).

All but one respondent would recommend their EPSRC fellowship to others and the vast majority were overwhelmingly positive about their fellowship experience.

Respondents from the Challenge Engineering scheme were particularly enthusiastic about this scheme with several previous holders asking EPSRC to bring it back.

"The Challenging Engineering scheme was transformational. It helped raise the profile of engineering and the fellowship holders have gone on to become leaders in their respective fields. This scheme was exceptionally good value for money and should be held up as an example of how a relatively small investment can truly build tomorrow's leaders."

Challenge Engineering Fellow

Such positive feedback on the EPSRC fellowship programme is also echoed by fellows through their input to Researchfish. In particular, one fellow commented that:

"At a personal level, I'm extremely grateful to EPSRC for the life-changing benefit of this Leadership Fellowship. It has given me a distinct identity and place in the research landscape, allowed me to pursue an area which ignites my strongest personal motivation, and as a happy by-product of the work funded by this grant, I was promoted to a Professorship in Cambridge from 1st October 2014. My only problem now is the wealth of opportunity that has been created by this work!"

Source: Researchfish

Box 1 Teaching load

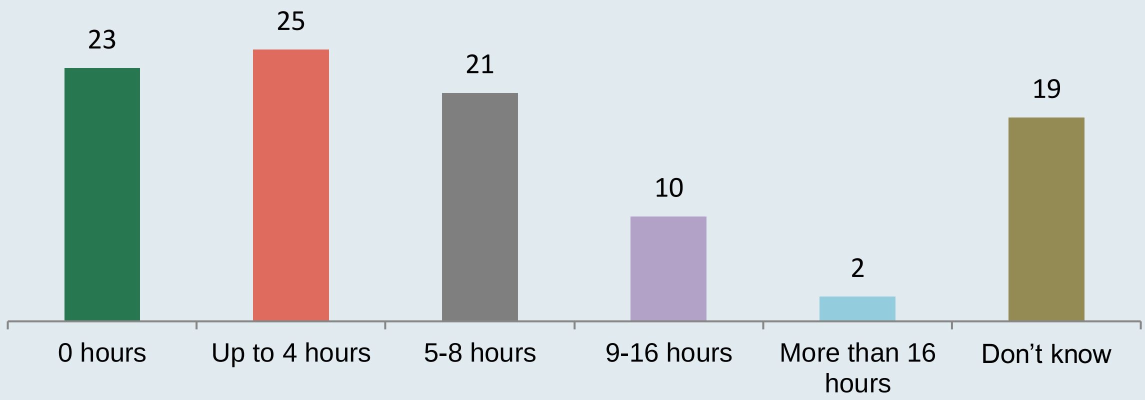
As highlighted above, one of the key features of the fellowships, and aspect that work well, has been the ability to dedicate time to research due mostly to a reduced teaching load.

Almost half of respondents agreed that their teaching load had been transferred to other researchers, while less than a third agreed that their teaching load had been transferred to a teaching fellow or equivalent (see Figure 12). There was considerable overlap, however, in these responses with only 17 respondents reporting that their teaching load had been transferred exclusively to teaching fellows.

Female respondents were, however, less likely to agree that they were able to commit (almost) all of their time to research (57%) or that their teaching load was transferred to other researchers (44%) or teaching fellows (25%).

Of the 135 respondents who reported that some of their teaching load was transferred, for a third of these this was up to 4 hours a week on average, with 27% transferring 5-8 hours a week. A quarter of these respondents did not know the amount of teaching responsibilities that were transferred.

Figure 12 Average weekly teaching load transferred (%, N=135)



One respondent offered a counterpoint to the advantage of reduced workload:

"I liked that the Challenging Engineering scheme had a strong focus on building leadership and hence some aspects of other fellowships (e.g. giving up teaching and admin) were not part of it. This enabled me to learn quickly how to be an academic leader who has to manage a team rather than being 100% on the work myself. I believe this enabled me to become a more rounded academic and opened up senior leadership roles."

Challenge Engineering Fellow

2.2.7 Areas of improvement (what work less well)

Respondents were asked about what features of their fellowship could have worked better with 82 respondents providing comments. A third of comments related to host support, in line with the findings above (as this equates to 13% of the overall sample). Key aspects highlighted include teaching and administrative load being higher than expected or agreed, access to resources being lower than expected or agreed, and lack of routes after fellowship (e.g. permanent position), which are also key original features.

As detailed above, few took issue with the application and administrative process.

When ask about feedback to EPSRC, some commented about the scheme design more generally which could serve to inform future iterations of the fellowships.

- **Broader thematic scope** - Most of the comments relating to fellowship conditions related to making the fellowship schemes open all EPSRC subject areas, rather than targeted to priority themes. One respondent specifically noted the potential impact on gender balance from a focus on priority themes. This could however reflect the fact that – by definition- the focus on priority areas means that the fellowships would have been relevant to only a sub-set of fellows. Some noted a disconnect between the focus on priority themes within different fellowships for different career stages and having a coherent career path for individual researchers.
- **Better balance of awards in terms of experience -** Although there are benefits from the openness of fellowship schemes in terms of the research experience of applicants, several respondents noted that this may have an unintended consequence of being less accessible to early career researchers, particularly recent doctoral graduates. Applicants with less experience may struggle to compete with applicants at the higher end of the eligibility range with more experience and stronger track records. If fellowship schemes continue to be open to a wide range of researchers in terms of experience, specific attention should be paid in peer-review panels to ensure a balance of awards across the

eligibility range and that reviewers are not (unconsciously) favouring applicants with more research experience.

- **Managing expectations -** For the early career fellowship schemes, some respondents reported disappointment in not achieving an expected permanent academic position following their fellowship. In terms of managing the expectations of fellowship holders, it appears that more clarity is needed by EPSRC and within the Host Agreement Statement as to the host institution's obligations at end of the fellowship, for example, whether that is the guarantee of a permanent position or the opportunity to apply for one. Respondents had mixed views on the offer of a permanent position with some proposing this should be a requirement of funding, while others were less convinced.
- **Commitment from Hosts** - A few respondents suggested that EPSRC could require host organisation to provide more specific written commitment of their support they would provide for a fellowship holder, including how much teaching and administrative responsibilities relief will be given and for EPSRC to follow-up on how this worked in practice.

3 Main benefits to fellows

In this section we present the main benefits emerging from participation in the fellowship, with focus on the fellows. We first present an overview of main benefits and then proceed to further unpack three key aspects: scientific production, career progression, and leverage of further investment. Scientific production and production of knowledge also have benefits that go beyond the fellows, as they also constitute societal goods, in their own right, and can lead to further economic and social benefits. These aspects are further explored in Section 4.

3.1 Overview

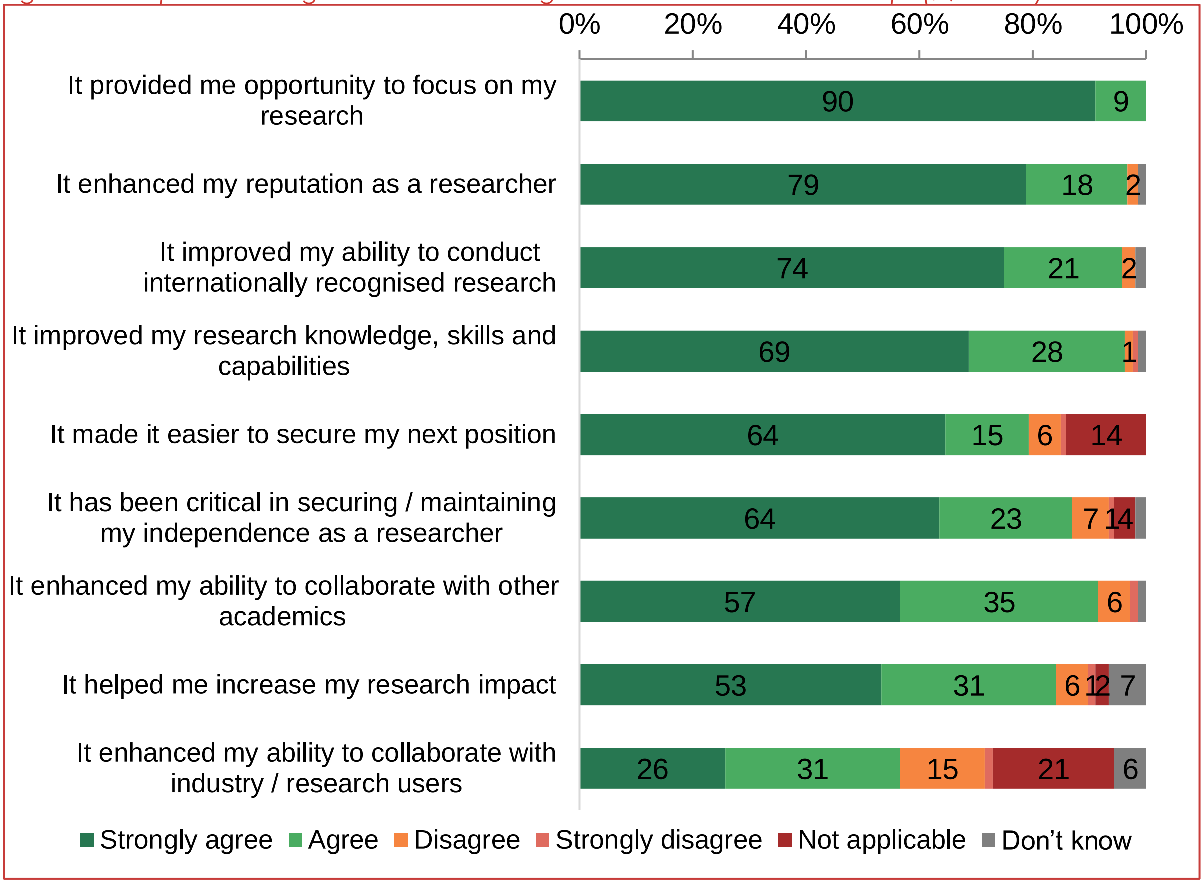
Survey respondents were asked whether they agreed with a range of possible benefits of their fellowship. Consistently, some of the benefits listed were also picked up in the key features of the fellowships (in Section 2.2 above) such as the opportunity to focus on their research and maintaining independence.

Furthermore, other aspects are revealed in this list with fellows agreeing or strongly agreeing that their fellowships also enhanced their reputation (97%), improved their ability to work internationally and increase their research impact (95% and 90% respectively) and supported the progression of the next stage of their career (79%). With the exception of the opportunity to collaborate with industry or research users, more than half of respondents strongly agreed with all the stated benefits of their fellowships.

Targeted fellowship respondents were significantly more likely to strongly agree that their fellowship helped increase their research impact (75%), enhanced their ability to collaborate with other academics (70%) and industry / research users (45%) compared with other types of fellowship. Unsurprisingly, established career fellowship respondents were least likely to strongly agree that it helped secure their next position (37%) or maintaining their independence as a researcher (40%).

Female respondents were more likely to strongly agree with most of the range of benefits of their fellowship than male respondents. However, there were no gender differences in the benefit of the fellowship in securing their next position or maintaining their independence as a researcher.

Figure 13 Respondents' agreement with a range of benefits of their fellowships (%, N=214)



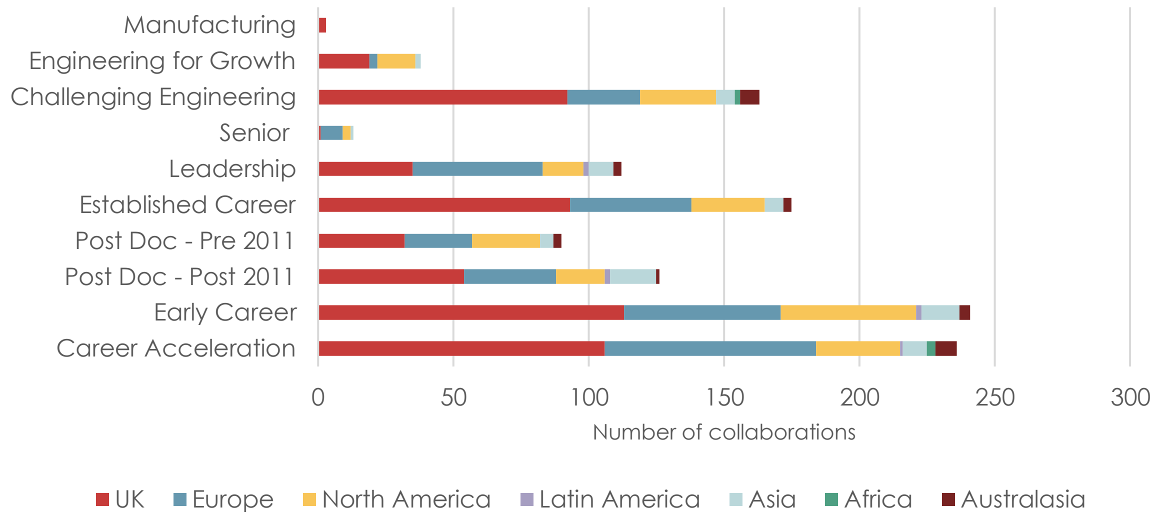
3.2 Collaborations

Collaboration is an important element of modern research activity. It can help to enhance "the quality and the creativity of the science product"[1] through bringing complementary expertise together and enabling cross-fertilisation of ideas. Although EPSRC fellowships are awarded to individuals rather than projects, collaboration with other researchers in academic and non-academic sectors as well as nationally and internationally features in proposals as well as ResearchFish submissions. Out of 603 fellowships, collaboration partners were reported for 288 fellowships at the proposal stage and for 269 fellowships during the life of the grant (according to ResearchFish).

EPSRC fellows most commonly have collaborations with partners located in the UK followed by Europe (Figure 1). Furthermore, partners are distributed globally – across all continents – which reinforces the international nature of the work conducted by the fellows. However, only a fourth of the pre-2011 postdoctoral fellowships (n=158) report collaborations (Figure 14).

Five fellows (three early career, one postdoctoral, one career acceleration) stated that their fellowships allowed them to concentrate on doing research and establish international interdisciplinary collaborations. One was able to work with computational biologists and statistical physicists working in Europe and the US leading to two influential papers in 2011 and 2012, while another was able to develop a network of international collaborators which led to winning a flagship H2020 grant (worth €4m). One of the early career fellows was able to pursue several collaborations in parallel as opposed to only one prior to receiving his fellowship.

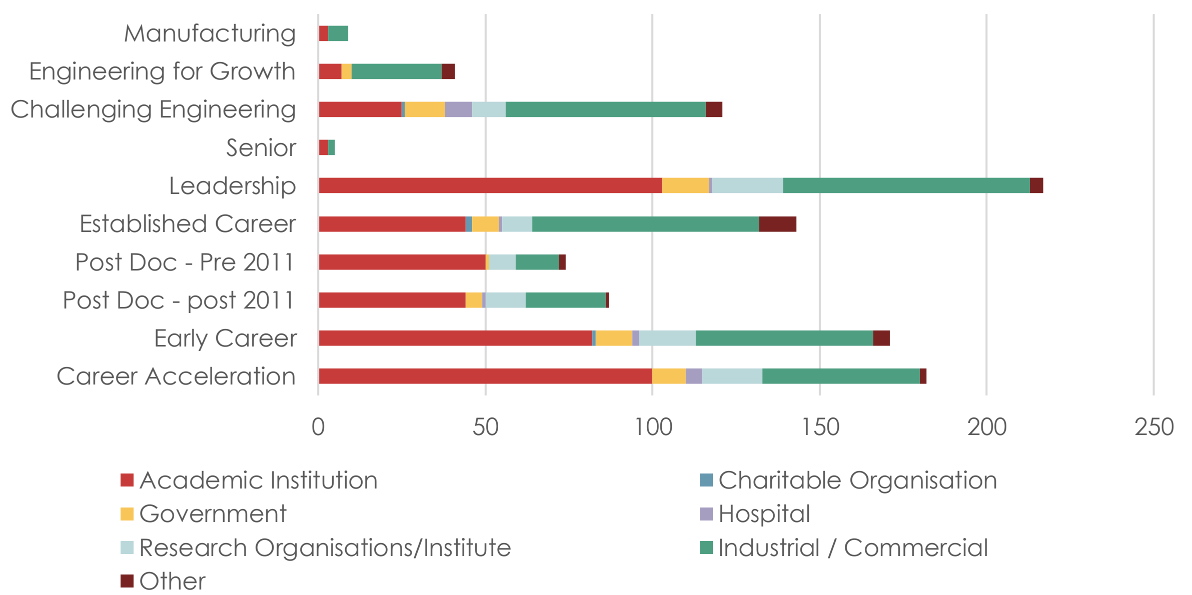
Figure 14 Location of collaborators by fellowship type



Source: Technopolis analysis of ResearchFish data

These collaborations include academic and industrial partners. Academic institutions and universities account for the most collaborations with 44% (462 out of 1051) of collaborations across all fellowships. Industrial and commercial organisations are the next most common collaborators accounting for 36% (374 out of 1051) of all collaborations (Figure 15). While academic collaborations dominated most fellowship types, the targeted fellowships (Challenging Engineering, Engineering for Growth and Manufacturing fellowships) and Established Career Fellowships had more industrial collaborations than academic ones.

Figure 15 Type of collaborator by fellowship type



Source: Technopolis analysis of EPSRC grant data

In our survey (n=211), 64% of respondents agreed or strongly agreed that their fellowship provided opportunities for academic collaboration but only 24% said the same about industrial collaborations. Nine fellows commented that the prestige of their fellowship had been instrumental in helping to set up collaborations, and 12 mentioned that their fellowship provided opportunities to visit overseas research groups and build international collaborations. On the other hand, 35% of respondents stated that their fellowship did not provide any opportunity for participation in industrial collaborations. Further, 92% and 57% of respondents overall felt that the fellowship improved their ability to collaborate with academia and industry/research users respectively (n=214).

However, targeted fellowship respondents were more likely to strongly agree that their fellowship helped increase their ability to collaborate with other academics (70%) and industry / research users (45%) compared with other types of fellowships. Moreover, female fellows were more likely to strongly agree that their fellowship improved their ability to collaborate with both academia and industry or other research users as well as provide opportunities for academic or industry collaboration.

Two Leadership Fellows stated that the reputational benefit conferred by this fellowship type provides leverage in developing research collaborations, and especially 'de-risks' industrial collaborations. One fellow was able to deepen his collaboration with AstraZeneca as a result of the fellowship, while the other was able to establish new methodology and won the Alexander von Humboldt research prize.

Collaborations also allow researchers to leverage finances (which is shown in Section 0)

3.3 Scientific production

3.3.1 Publications

Building up a strong publication record is an important activity on the road to research independence and success. The fellowships provided them with the opportunity to build up their publication records that they otherwise would not have been able to access just with grant funding. In total, **the EPSRC Fellowships has contributed to the publication of 11,775 research papers,** according to Researchfish. Figure 16 presents the breakdown of fellows' publications by fellowship type. Career acceleration and Leadership fellows have contributed to the largest proportions of the volume of papers, publishing 24% and 21% of the total number of publications. On average, the fellows published 19.5 papers that were made possible with support from the EPSRC grant funding. The type of fellows that published most are Leadership fellows (35.5 papers), and Established Career (31.1 papers) Engineering for Growth fellows (30.6 papers). Pre- and post-2011 Post-Doctoral fellows contributed 972 (8%) and 485 (4%) of these respectively and published relatively less, between 6 and 10 papers on average.

"This funding has led to the publication of 14 papers. I was first author on six of these papers including two in 'Ecology Letters'. I was second of two in authorship for two further papers, one of which was in 'Systematic Biology'. There are several further first author works that benefited from the funding and are expected to appear soon but are not yet accepted. I have given 28 research presentations during the grant including 12 at international conferences. - Postdoc Research Fellowship:"

Source: Researchfish

Figure 16 Total number of papers, by Fellowship type

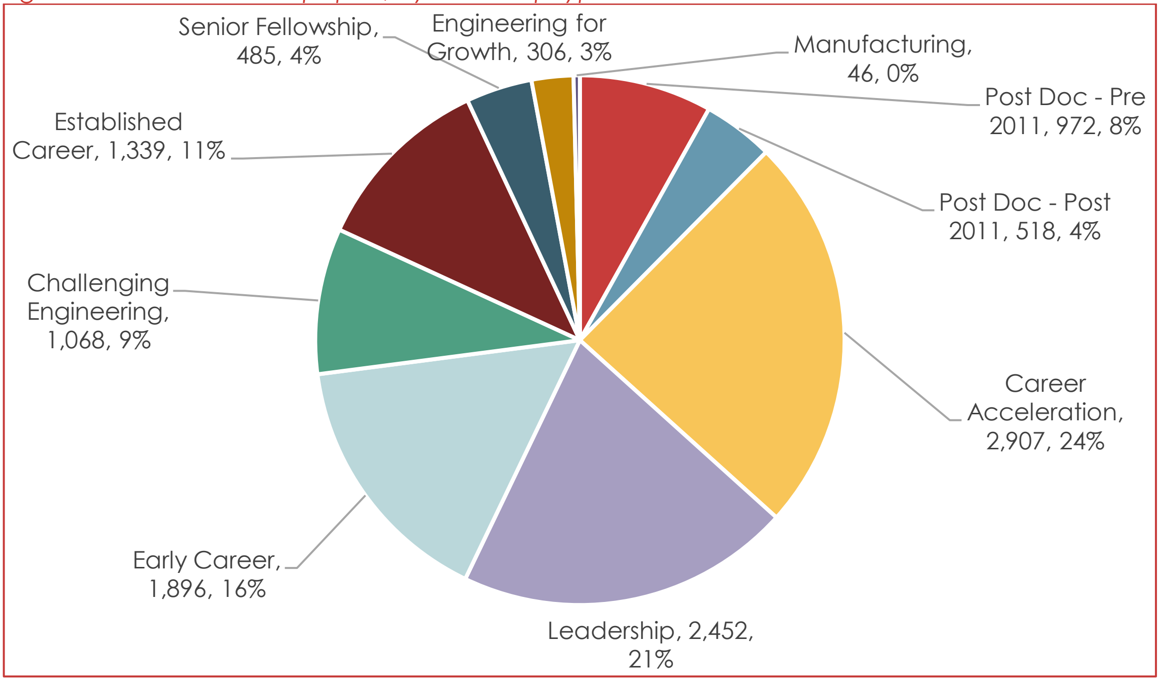
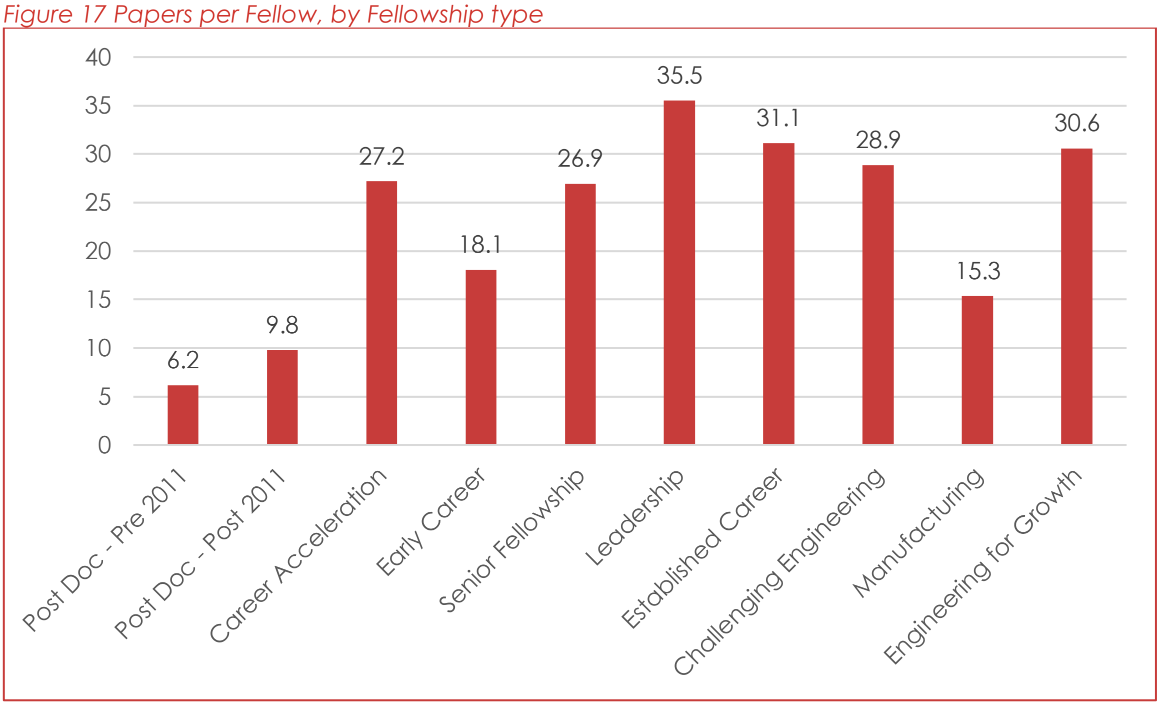


Figure 17 Papers per Fellow, by Fellowship type



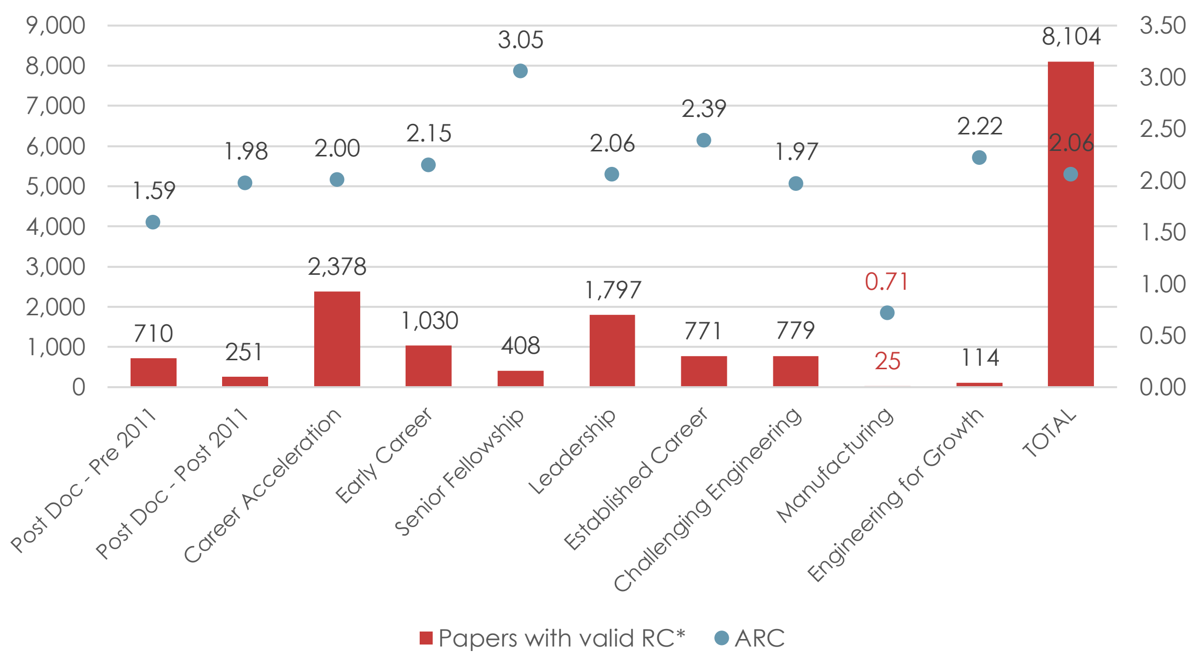
3.3.2 *Citation impact*

As shown in Section 3.1 above, fellows agree or strongly agree that the fellowships increase their research impact (90%). We explore this further with bibliometric data. Figure 18 shows 8,104 papers with a valid Relative Citation (RC) score for which impact bibliometrics are computed.

This chart also shows the average of relative citations (ARC)[3]. **Papers published by EPSRC fellows have an Average Relative Citation (ARC) score of 2.06,[4] meaning that these papers are twice as likely to be cited than the world level (i.e. 1.0).** This is in line with similar impact measures for the EPSRC as a whole (e.g. 2.06 in Field-Weighted Citation Impact[5]).

Post-docs also represent positive results as compared to world levels. Papers published by pre-2011 Post-Doctoral fellows have an ARC score of 1.59, meaning that they are cited 59% more than the world level. Post-2011 Post-Doctoral fellows' papers are cited 98% more than the world level. On the whole pre- and post-2011 Post-Doctoral fellows' publications performed largely below the fellowships average but consistently above world level in all measures. This largely reflects the career stage of fellows at post-doctoral level who are still in the early stages of their careers. The ARC score of senior fellows is 3.05, meaning that papers published by these fellows are, on average, three times as likely to be cited than the world level.

Figure 18 Papers with valid Relative Citation (RC) and Average of Relative Citations (ARC), by Fellowship type



Note that impact indicators are usually not computed for aggregates with less than 30 RC scores. However, the constraint was relaxed here to provide more insight on performances at a disaggregated level, i.e. for Manufacturing fellows as presented in red. Caution is advised when interpreting these data points as they are prone to fluctuations due to extreme values and outliers.

[3] ARC shows how often an institution's or researcher's papers are cited, normalised for subfield and year of publication. The indicator is normalised to 1.0, which represents the world level; a score of 1.2 would mean that the papers are cited 20% more than the world level, whereas a score of 0.8 would mean that the papers are cited 20% less than the world level.

[4] 8,104 papers have a valid RC (Relative Citation): publication sets from which citation-based bibliometric indicators are computed. Only papers published in 2017 or earlier have an RC score.

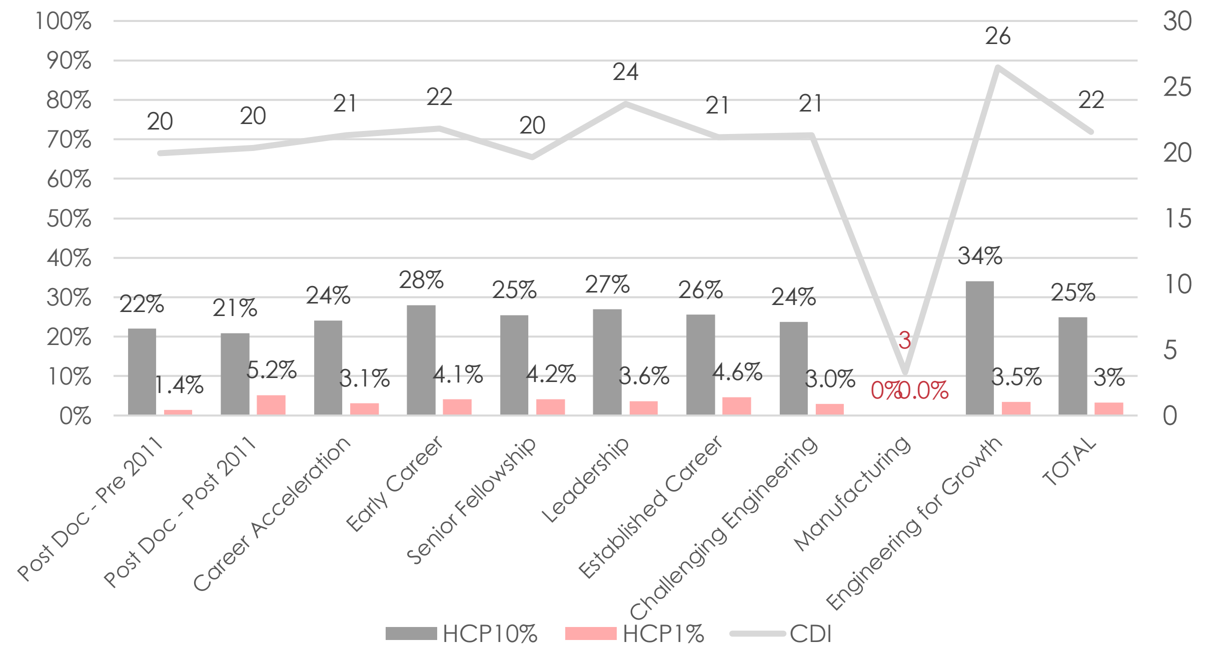
[5] https://epsrc.ukri.org/newsevents/pubs/publicationsanalysis/

Figure 19 presents the share of Highly Cited Publications (HCP) for the top 10% and 1% of the respective field where fellows publish their research.[6] Based on the portfolio of papers, **EPSRC fellows contributed 25% to their fields' top HCP 10% and 3% to their fields' top HCP 1%.**

Pre- and post-2011 Post-Doctoral fellows contributed 22% and 21% to their fields' top HCP10% respectively, lower than the average across fellowships but still positive overall. As for HCP1%, pre-2011 fellows contributed 1.4%, the lowest across fellowships types, whereas post-2011 fellows contributed 5.2%, the highest across all fellowship types. Engineering for Growth fellows contributed 34% to their fields' top HCP10%, which is higher than other fellows.

The final indicator also shown in Figure 19 (used to complement the ARC) is the citation distribution index (CDI). Whereas the HCP10% examines contributions to the most impactful decile, the CDI considers contributions to each decile, and then integrates these contributions into a single score.[7] **The Citation Distribution Index (CDI) for the total volume of papers is 22**, well above the world level.

Figure 19 Highly Cited Papers - 10% & 1%, by Fellowship type



Note that impact indicators are usually not computed for aggregates with less than 30 RC scores. However, the constraint was relaxed here to provide more insight on performances at a disaggregated level, i.e. for Manufacturing fellows as presented in red. Caution is advised when interpreting these data points as they are prone to fluctuations due to extreme values and outliers.

The citation impact analysis shows that EPSRC fellows/alumni contribute to their research field, altogether suggesting that the Fellowship is a prestigious award that is impactful on the

[6] Highly cited papers are publications that have received the highest relative citation scores in their respective field, expressed as the share of an entity's portfolio. This indicator measures how many high-impact articles are produced by a given research entity, relative to their expected contribution to world-leading research. World reference are respectively 10% and 1% by subfield.

[7] The CDI score ranges from -50 (theoretical minimum, seldom seen in practice) to -25 (a very low score that one might actually observe) to 0 (the world level) to 25 (a very high score that one might actually observe) to 50 (theoretical maximum, seldom seen in practice). http://cins.ca/docs/SM_CNBC_Bibliometric_Analysis.pdf

research landscape. One senior fellow reported (in Researchfish) that the fellowship "helped receive the Nobel prize."

There are seven disciplines where EPSRC fellows have published and citations are above the Relative Citation (RC) scores. The seven disciplines are:

1. Chemistry
2. Clinical Medicine
3. Enabling & Strategic Technologies
4. Engineering
5. Information & Communication Technologies
6. Mathematics & Statistics
7. Physics & Astronomy

The top three papers are listed in Table 3 and the top 10 is listed in the Appendix C.

Table 3 Top three most cited publications, by discipline

Discipline	Citations	RC	Title	Journal
Chemistry	873	38.3	Ionic transport in hybrid lead iodide perovskite solar cells	Nature Communications
	417	38.1	A Dysprosium Metallocene Single-Molecule Magnet Functioning at the Axial Limit	Angewandte Chemie - International Edition
	405	29.7	Technologies for printing sensors and electronics over large flexible substrates: A review	IEEE Sensors Journal
Clinical Medicine	825	36.1	NODDI: Practical in vivo neurite orientation dispersion and density imaging of the human brain	NeuroImage
	351	24.1	Decreased gut microbiota diversity, delayed Bacteroidetes colonisation and reduced Th1 responses in infants delivered by Caesarean section	Gut
	248	17.8	Shaping cities for health: Complexity and the planning of urban environments in the 21st century	The Lancet
Enabling & Strategic Technologies	6061	146.9	UCHIME improves sensitivity and speed of chimera detection	Bioinformatics
	537	45.6	Reversible hydration of CH3NH3PbI3 in films, single crystals, and solar cells	Chemistry of Materials
	348	45.3	What is LiFi?	Journal of Lightwave Technology
Engineering	349	29.3	SUDS, LID, BMPs, WSUD and more – The evolution and application of terminology surrounding urban drainage	Urban Water Journal
	168	26.5	1 year, 1000 km: The Oxford RobotCar dataset	International Journal of Robotics Research
	943	23.0	Review of bioactive glass: From Hench to hybrids	Acta Biomaterialia
Information & Communication Technologies	782	56.7	Spatial modulation for generalized MIMO: Challenges, opportunities, and implementation	Proceedings of the IEEE
	726	46.4	BUBBLE Rap: Social-based forwarding in delay-tolerant networks	IEEE Transactions on Mobile Computing

	203	38.2	HermiT: An OWL 2 Reasoner	Journal of Automated Reasoning
Mathematics & Statistics	135	28.4	Smoothing Parameter and Model Selection for General Smooth Models	Journal of the American Statistical Association
	40	18.8	Breaking the coherence barrier: A new theory for compressed sensing	Forum of Mathematics, Sigma
	126	15.2	On particle methods for parameter estimation in state-space models	Statistical Science
Physics & Astronomy	5182	204.9	Fine structure constant defines visual transparency of graphene	Science
	2780	132.5	Control of graphene's properties by reversible hydrogenation: Evidence for graphane	Science
	8652	87.5	Graphene: Status and prospects	Science

3.3.3 *Disruptive thinking*

There has been substantial attention and investment towards funding research that is, in some way, ground-breaking and or transformative, with some UK councils having set up specific funds to try to encourage a degree of risk taking and 'disruptive thinking'. The funding of research that is multidisciplinary is also something that is being recognised as important, but also recognised as sometimes challenging for researchers due to barriers in sourcing (future) funding, publishing research outcomes etc, as discussed in the wider literature.

Defining what is disruptive and/or transformational involves considering various dimensions, i.e. disruptive thinking can involve interdisciplinary research, research with high risks attached, research that builds on novel methods or applications, etc. It may be that many such dimensions (from the perspective of the researcher) are connected.

EPSRC fellowship alumni were asked to indicate to what extent they agree or disagree with a number of transformational aspects of their research (carried out during the Fellowship). The results, as illustrated by means of Figure 20 and

Table 4, show that the majority of alumni surveyed find that their research was 'transformative' across multiple dimensions. **91% of respondents strongly agree/agree that the scope of the project was such that successful results could be transformational in its field**. Moreover 77% of respondents strongly agree/agree that achieving significant results from the research was likely to require long time frames and follow-up funding.

91% of respondents commented that their project *aimed* to achieve a major methodological or theoretical innovation out of which 85% believed that it had *achieved* a major methodological or theoretical innovation. This result does not suggest that the majority of projects involved a high risk, which is somewhat corroborated by the findings, i.e. 21% strongly agree that their project involved an unusually high degree of risk in terms of likelihood to achieve successful research results (strongly agree/agree – 65%). In relation, one interviewee, a senior fellow, commented that the fellowship enabled dedicating large chunks of time to: "thinking about 'hard, adventurous, long-term problems"

59% of respondents strongly agree/agree that results of their project (if successful) would have wide application outside of academia. It is of course possible that researchers may not be able to anticipate the wider application of their research.

80% of respondents strongly agree/agree that their project represented a novel application of theory or methods to a new context. Data from Researchfish corroborates this finding and shows that EPSRC fellows are also generating impact within research. There are 234 (valid) entries from EPSRC fellows/alumni detailing impact from research materials, tools and methods. 185 entries related to the development of software, 23 entries relate to the development of a webtool application, 14 relate to the development of a new/improved technique or technology, and another 12 entries are classified differently. Software development are reported to be used by several researchers in further research, by themselves and by others and for example, such software packages are commented to have been downloaded by other users. As an example, a software developed by a fellow led to the formation of GraphicsFuzz, a spinout company, which was subsequently bought by Google. One specific example of a webtool application is the development of a security patch in response to the discovery of bugs in the Mozilla Firefox browser. Further evidence on innovations is presented in Section 4.2.

"I wrote two connected papers that represent a totally new way of thinking about an important problem. This is the most conceptually original and important work I've done in my career."

Post-doc post-2011

Figure 20 Respondents' agreement with the transformational aspects of their research (N=204)

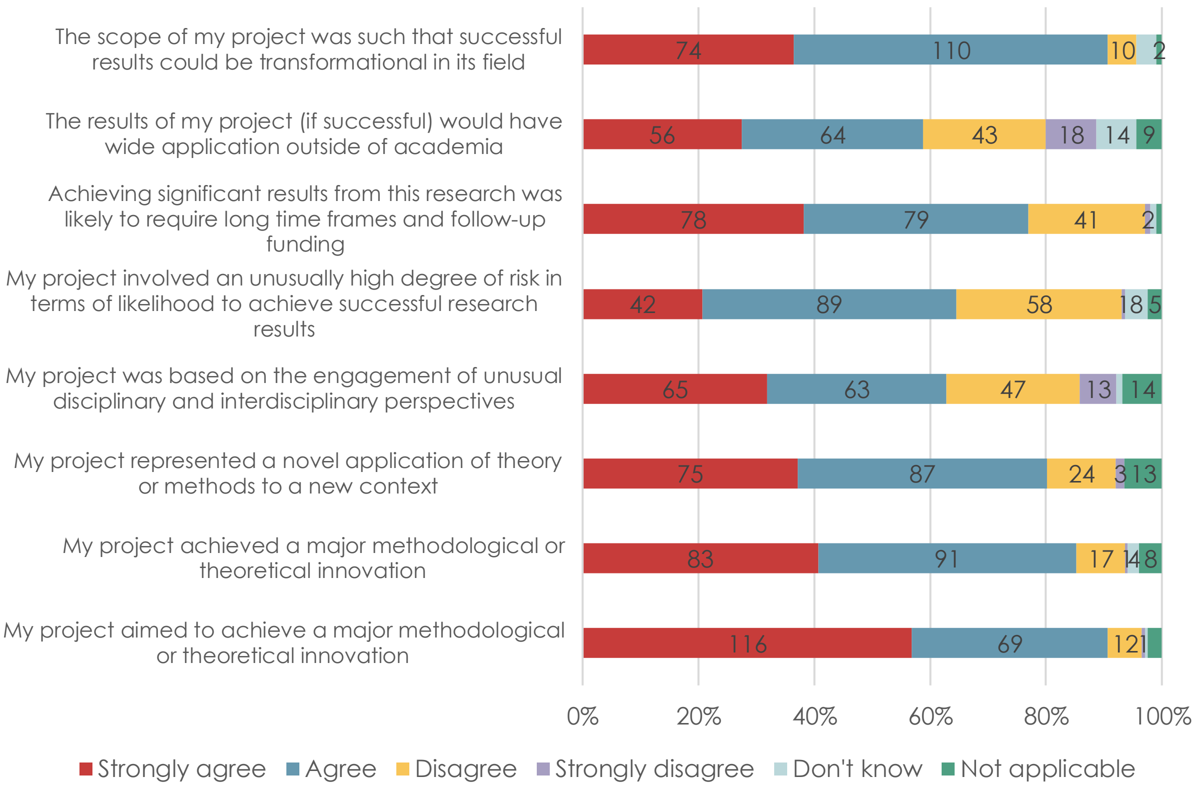


Table 4 Respondents' agreement with the transformational aspects of their research (N=204), %

	Strongly agree	Agree	Disagree	Strongly disagree	Don't know	Not appli-cable
My project aimed to achieve a major methodological or theoretical innovation	57%	34%	6%	0%	0%	2%
My project achieved a major methodological or theoretical innovation	41%	45%	8%	0%	2%	4%
My project represented a novel application of theory or methods to a new context	37%	43%	12%	1%	0%	6%
My project was based on the engagement of unusual disciplinary and interdisciplinary perspectives	32%	31%	23%	6%	1%	7%
My project involved an unusually high degree of risk in terms of likelihood to achieve successful research results	21%	44%	29%	0%	4%	2%
The results of my project (if successful) would have wide application outside of academia	27%	31%	21%	9%	7%	4%
Achieving significant results from this research was likely to require long time frames and follow-up funding	38%	39%	20%	1%	1%	1%
The scope of my project was such that successful results could be transformational in its field	36%	54%	5%	0%	3%	1%

Table 5 Evidence from interview – Postdoctoral fellow

2017 (Russell Group University)

In its combination of goals the researchers' Fellowship proposal aimed to achieve 'a good balance of risk and return'. A key benefit of the Fellowship was:

"It allowed me to think about some really high risk projects, because I'd already produced quite a lot and… identified some important problems, and it gave me time to think about them, whereas I don't know if I would've done that if I wasn't on the Fellowship because it requires a lot of time and concentration to work on difficult projects and it may be a little risky - if you don't have much time to do research you want to focus on things that will definitely produce research outputs."

The Fellowship exceeded the fellow's expectations, both in terms of quality and adventurousness of her research output. In her experience, the Fellowship scheme "was as perfect as I could've imagined it".

Two papers in particular led to a new way about thinking about a statistical problem that has major implications for scientific research. The work was written up as some computer code, initially by her then re-written in a language more widely used by different scientists who use statistics. That open-access software has so far been downloaded around 11,000 times – making the largest impact of anything in her career to date

Table 6 Evidence from interview – Challenging engineering fellow

2008 (Leeds) Now Professor of Biomedical Engineering, University of Leeds

EPSRC's Challenging Engineering scheme, focussed on engineering career paths and pushing the boundaries of Engineering was highly attractive to the researcher when she was considering funding opportunities thirteen years ago. Her field of medical engineering – applying engineering principles to medical devices - was new and involved a lot of collaboration with medics and biologists.

"The Fellowship proved to be great for allowing me to try out high risk things in interdisciplinary work, because if something didn't work out I had flexibility to move funds elsewhere. Work on grant funding 'wouldn't have been anywhere near as boundary pushing as I was able to do with the Fellowship"

63% of respondents 'agree/strongly agree' that their research was based on the engagement of unusual disciplinary and interdisciplinary perspectives. Data on 'subjects' taken from the 'Gateway to Research' corroborates this finding. The database holds information for 553 or 92% of the 603 investigated fellowships and research grants. Out of the fellowships that have data available, 33% (197) are associated with multiple subjects/discipline – see Table 7.

Table 7 Fellows conducting research across multiple subjects/disciplines

	Number of fellows	Percentage
Total number of fellowships funded	603	
Number of fellows with data on subject	553	
Number of fellows with data on a second subject	197	33% [197 of 603]
Number of fellows with data on a third subject	50	8% [50 of 603]
Number of fellows with data on a fourth subject	7	1% [7 of 603]

3.4 Career progression

3.4.1 Overview

Respondents were asked the extent to which they agreed that their fellowship had impacted on their career. **93% agreed that it had made a significant difference to their career path 86% of respondents agreed that it had impacted on the level of seniority they had reached, with similar proportions agreeing they had made faster career progression than they would have done without it.**

54% agreed that it was easier to secure a permanent position after their fellowship, with this increasing to 74% for early career respondents, with 15% saying this was not applicable. 11% of early career respondents disagreed that it had helped them secure a permanent position. 30% of targeted fellow respondents strongly agreed that their fellowship had helped secure a permanent position, with 65% reporting this was not applicable. Targeted fellowship respondents were more likely to agree that their fellowship had an impact on their careers, with 90% strongly agreeing that it had made a significant difference to their career path and 85% strongly agreeing it had facilitated faster career progression.

Established career respondents were most likely to strongly agree (71%) that their fellowship had enhanced the way senior colleagues perceived them.

There were small gender differences in the value of their fellowship in securing a permanent position with 40% of female respondents and 47% of male respondents strongly agreeing. 13% of female respondents disagreed (9% male), while 40% of female and 35% of male respondents reported this was not applicable to them.

Figure 21 Impact of fellowship on career (%, N=214)

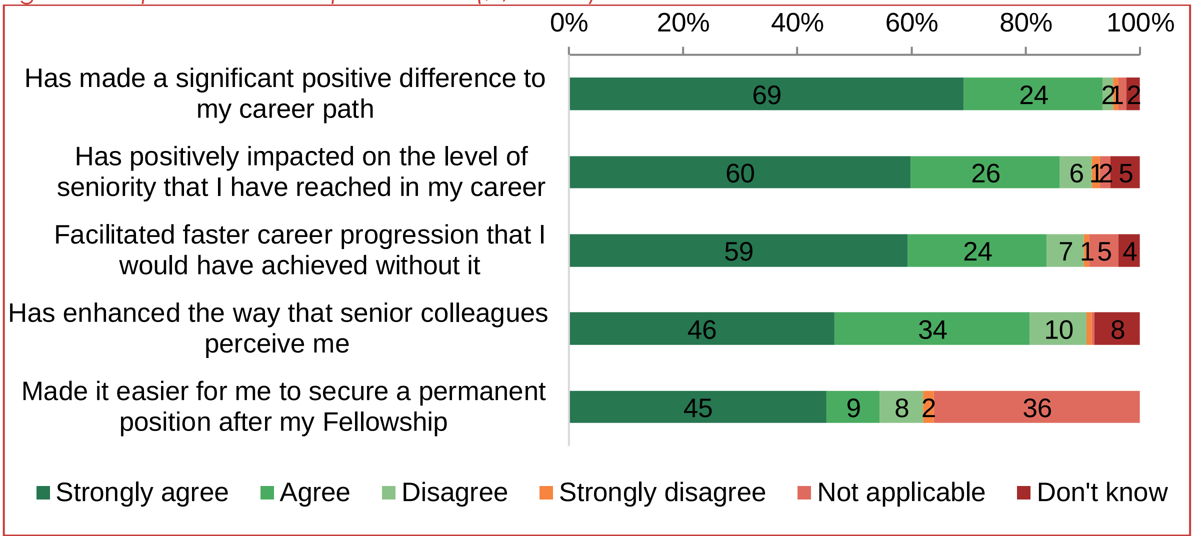


Table 8 Evidence from interview – Early career fellowship

2013 (Manchester) now Professor of Molecular Materials, University of Manchester
The Fellowship gave the researcher's career a strong push: during it he received two promotions. When he applied for the Fellowship he was a Senior Lecturer; the year after he became a Reader. In 2016 he was promoted to a Chair. It was a large Fellowship and the way he used it 'ticked all the criteria needed for promotion': international reputation, publication of papers, and so forth. The period of the Fellowship had allowed him to 'sidestep some of the mid-level jobs'. *After it ended he was able to 'move toward the research administration side of the department, taking on more research focussed duties which are of more interest to me - and teaching, of course. I was able to develop new teaching materials relating to work done during the Fellowship.'* He returned as a line manager with more senior roles, and is, for example impact lead for the department.

Table 9 Evidence from interview – Postdoctoral fellowship

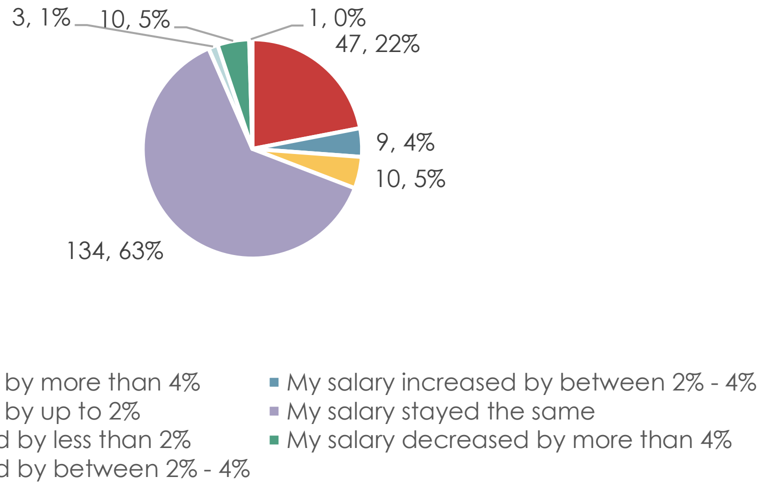
2009 (Leicester), now Team Leader, New Modalities Chemistry, AstraZeneca, Gothenburg
He had recently finished his PhD from MPI Tuebingen, and just started a postdoctoral position at the University of Leicester, when he was encouraged by his supervisor and other professors to apply for an EPSRC Fellowship. He was particularly attracted by the control over his time it would give him and the "flexibility to think about what's really important in my research direction". The Fellowship gave the researcher many opportunities beyond the experience of most research staff less than a year out of their doctorate, including: - Further expanding research ability and learning how to manage the funding: "these became the springboard to enhance my academic career" - Developing multiple academic collaborations in the UK - Relationship with Royal Society of Chemistry, especially the medicinal chemistry panel - Co-supervising two PhD students and having own Masters' students on the project - Departmental admin/'understanding how funding worked and how professors develop research groups - Developing international networks, including collaborators in the USA he is still working with

3.4.2 *Wage premia*

It is anticipated that career advancement enabled by the fellowships, described above, would have an impact on the fellows current and future salary.

Survey evidence shows that the majority of respondents (63%) experienced no change in salary immediately following the end of the Fellowship. A minority (7%) experienced a decrease, which may be because some researchers were in-between jobs at the end of the fellowship. 31% reported an increase in salary – see Figure 22. The average salary increase is assumed to be 1.04%. Based on these survey results, it is assumed that alumni will benefit from a small wage premium (i.e. 1.04%) that is earned on top of the base salary, for the remainder of their career, from the start of the fellowship until they retire at age 61[8]. This estimate feeds into our modelling for the economic assessment of the impact of the fellowships (presented in Section 1).

Figure 22 Survey questions - What happened to your salary immediately after the end of your Fellowship compared to your salary during the Fellowship? N=214



3.5 Leverage and further investment

As reported in Section 3.2, the fellowships have enabled the fellows to work collaboratively. Collaborations allow researchers to **leverage finances**, both in cash and in kind, from partners, providing greater resources to spend on research activity. For an EPSRC contribution of £339 million across 603 fellowships, £43m was leveraged from partners (£2m in cash and £41m in kind) across 288 fellowships (Figure 23). As such, £0.11 was leveraged for each pound spent by EPSRC.

Figure 23 Financial contributions by EPSRC and collaboration partners (in cash and in kind)

Fellowship type	Total number of awards	EPSRC contribution (£)	Number of awards with partner contributions	Partner contribution (£)	leverage (£ per pound spent)
Post-doctoral (Pre 2011)	158	35,516,705	38	1,381,339	0.04
Post-doctoral (Post 2011)	53	13,888,120	28	4,966,404	0.36
Career Acceleration	107	80,110,457	59	3,206,905	0.04

[8] This wage premium estimate is a conservative estimated relative to the 12% wage premium which researchers are estimated to earn over a career spanning 40 years, in relation to having undertaken a 1+ year training at CERN, see: http://cds.cern.ch/record/2635864/files/CERN-ACC-2018-0025.pdf?version= and Florio et al (2015). Researchers at CERN spent at least a year in training.

Fellowship type	Total number of awards	EPSRC contribution (£)	Number of awards with partner contributions	Partner contribution (£)	leverage (£ per pound spent)
Early Career	105	76,525,353	53	6,736,018	0.09
Senior	18	12,145,825	2	5,250,814	0.43
Leadership	69	83,885,064	46	10,002,530	0.12
Established Career	43	49,529,158	27	3,733,974	0.08
Challenging Engineering	37	34,185,004	24	6,522,550	0.19
Manufacturing	3	3,553,495	3	863,000	0.24
Engineering for Growth	10	9,695,519	8	761,757	0.08
Total	**603**	**399,034,700**	**288**	**43,425,291**	**0.11**

Source: Technopolis analysis of EPSRC grant data

Of the £43 million raised from partners, £19 million and £16 million were provided by academic and industrial partners respectively with an average of around £42,000 per collaboration (Figure 24). Only government partners offered collaborations of a higher average value. However, it should be noted that most (96%) of the contributions were in-kind.

Figure 24 Amount leveraged by collaborator type

Collaborator type	Total amount leveraged (£)	Number of collaborations	Average value (£)
Academic Institution	19,185,552	462	41,527
Industrial / Commercial	15,890,573	374	42,488
Government	3,853,063	64	60,204
Research Organisations/Institute	3,251,127	95	34,222
Other	667,702	34	19,638
Hospital	530,631	18	29,480
Charitable Organisation	46,643	4	11,661
Total	**43,425,291**	**1,051**	**41,318**

Source: Technopolis analysis of EPSRC grant data

The EPSRC fellowships allow researchers to attract **further funding** to help progress with their research agendas. This is either because of the attractiveness of their research, and the scientific or technological progresses they are able to make during the fellowship (both of which attracts further funding opportunities); or because of the prestige associated to the fellowship, which allows them to advance or consolidate their careers (making them more able to draw on national and international resources).

There are 1,206 entries in Researchfish providing details on further funding opportunities[9] which includes data from 301 fellows, 50% of the 603 EPSRC Fellowships. The EPSRC Fellowship alumni have reported on £809.1m of further funding, which is double the total value of the EPSRC fellowships (£339.0m).

The type of further funding awarded includes (other) fellowships (10%), research grants (64%), studentships (12%), Travel grants/small personal grants (10%), and (capital and infrastructure funding - 4%)

A relative high percentage of further funding comes from international sources, which could be seen as an economic impact emerging from the fellowships, in so far this constitutes additional resources for the UK research community. More than 200 different organisations have provided further funding to EPSRC Fellowship alumni. The biggest provider of further funding EPSRC Fellowship alumni is the EPSRC, providing around 31% (377) of further funding opportunities and 61% of all further funding received, i.e. £493.8m. This also amounts to 74% of further public funding.

The European Union has been another big provider of further funding opportunities with 142 (12%) further funding opportunities coming from EU funding sources (e.g. H2020, ERC, COST, Marie Sklodowska-Curie Actions). Other major public funders include The Royal Society and the Biotechnology, Biological Sciences Research Council (BBSRC) and Innovate UK (5%, 3% and 2% responsively). Charitable funding includes funding from the Wellcome Trust (1%).

Table 10 provides an overview of the number and value of further funding that EPSRC fellowship alumni received, by stakeholder type. The data shows that public funders are the biggest source of further funding.

Academia and charitable organisations are both providing around 18% of further opportunities, and 7% of further funding. Industry is providing smaller further funding opportunities, with the average grant size received by industry, £456k, being substantially below the total average, i.e. £675k.

Table 10 Number and value of further funding by stakeholder type

Stakeholder type	**Number of further funding grants**	**Number of further funding grants (%)**	**Average value**	**Total value**	**Total value (%)**
Public	647	54%	£1,038,769	£670,006,147	83%
Academic/University	214	18%	£265,342	£56,252,544	7%
Charity/Non Profit	216	18%	£264,213	£56,805,822	7%
Private	101	8%	£156,172	£15,773,338	2%
Learned Society	4	0%	£3,846	£15,383	0%
[not labelled]	21	2%	£489,084	£10,270,763	1%
Total	**1,203**	**100%**	**£675,396**	**£809,123,997**	**100%**

[9] A total number of 1,286 entries are reported in Researchfish. This includes seven entries that are not considered in the analysis because the reported funding data precedes the award of the fellowship. The analysis also excludes a number of likely duplicate entries.

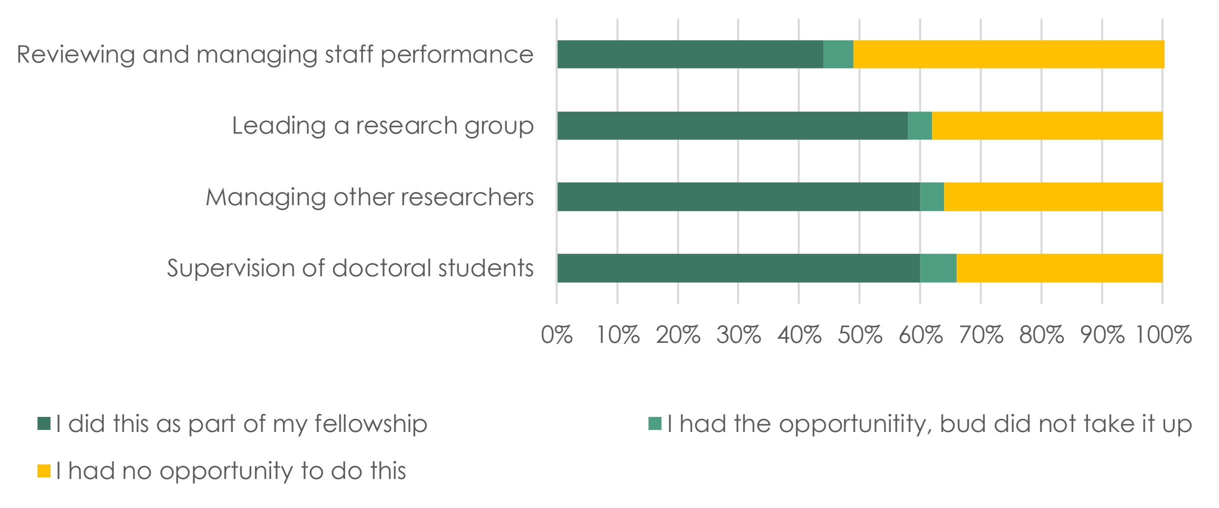
4 Impact to the economy and society

In this section we focus on the impact of the fellowships (and the fellows activities) on development of skills and capacities (via access to training opportunities for the fellows' research group), innovation and on wider impact to the economy and society. Where possible, we have tried to monetise this impact to inform our economic assessment (Section 1).

4.1 Skills and capabilities

Fellows have contributed to the training of the next generation of researchers, supervising doctoral researchers, managing other researchers and leading a research group, and reviewing and managing staff performance during their fellowship.

Figure 25 Participation in training of others (%, N=189)



Other derived benefit from the fellowships is the access to training opportunities for the fellow's research groups.

Respondents that had hired researchers as a result of their fellowship funding were asked to identify the training opportunities that these researchers had access to that would not have happened without their fellowship. 103 fellows responded to this question identifying a wide range of training activities from collaboration and teamworking (61%) through to responsible innovation training (14%).

However, on reviewing the comments relating to this question, it is likely that respondents replied on the basis of the training that was generally available within the institution, rather than specific training that was only available as a result of the fellowship funding. Nevertheless, this does give an idea of the balance of training that these group members were receiving.

Additionally, building their research group and training the next generation of researchers came through as a strong benefit of the fellowship in the survey.

Figure 26 Research group access to training opportunities (%, N=103)

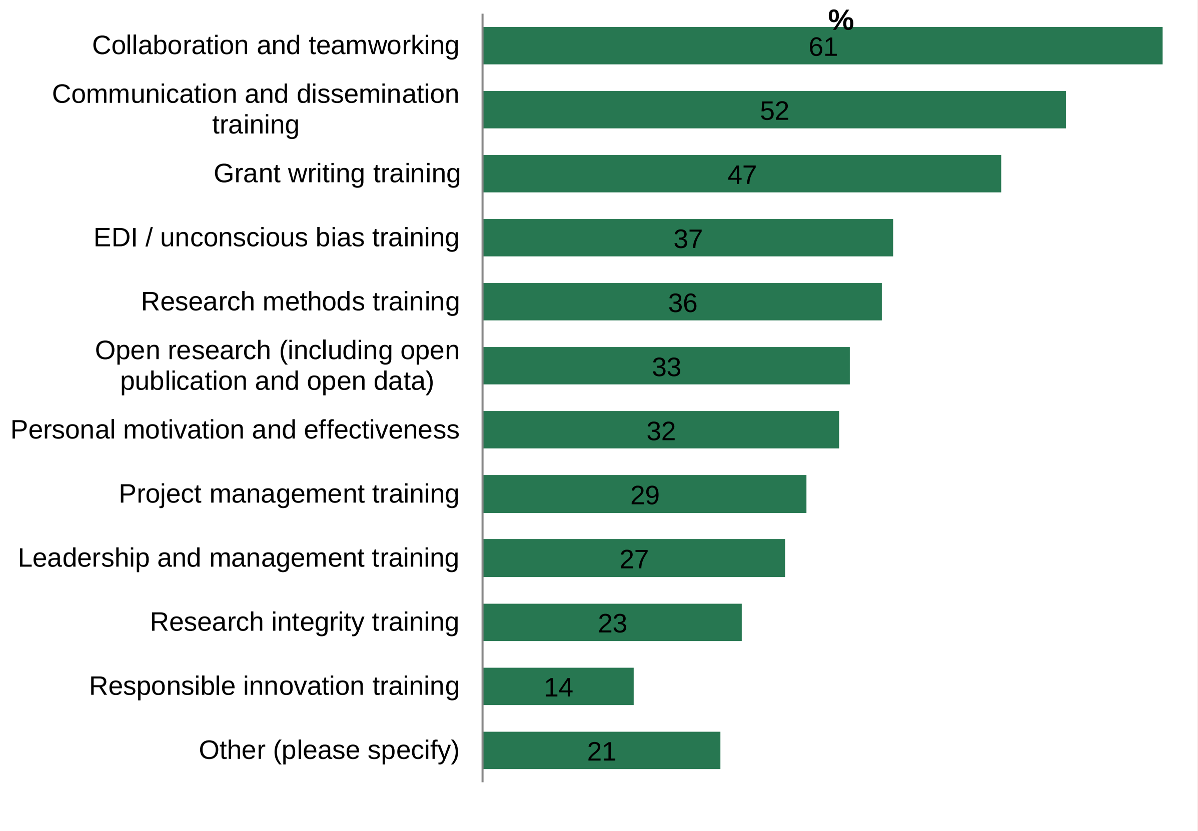


Table 11 Evidence from interview – Manufacturing fellowship

2013 (Exeter/Oxford) "Training and development of others was an important benefit of the Fellowship: a well-resourced group is a godsend for the people who are working in the research group and …because I had the EPSRC Fellowship I could use these resources flexibly... for example, sending students abroad to my collaborators at other institutes to…work on new ideas". "I used my Fellowship to some extent to train people in the experiential aspects, of not just the science, but also the management experience and leadership experience to actually make things happen."

Table 12 Evidence from interview – Early Career fellowship

2012 (applied from Oxford but moved to Sheffield) Now Senior Lecturer in Materials Science and Engineering, University of Sheffield Having time for team development was highly important. The Fellowship gave the researcher the confidence to manage a team of his own (without any formal management/leadership training) and this gave him the confidence to manage a team of other academics on a much larger project later. - 'I think the biggest difference the Fellowship offered me was the amount of time I could dedicate to my team. I could be more proactive in developing them and their careers' - 'Time with the team gave a really good foundation for building up the [new] lab [at Sheffield] because the team was tight.' - 'What I enjoyed the most in my Fellowship was using resources given to me during that time to really focus on and to support the career development of others'

4.2 Innovation

There are a series of innovation outcomes emerging from the fellowships, including the creation of spin outs (and the new jobs associated with them) and new inventions (and its proxy, patents) associated to fellows, as well as further knowledge flows that also materialised into new inventions in the wider society.

4.2.1 Spin-outs and jobs created

To date, 50 EPSRC fellowships from 2006-2016 contributed to the creation/development of spinouts. It is worth noting, that other EPSRC grants contributed to the creation/development of more than one spinout and some spinouts benefitted as these are supported by developments that emerge over time, including the inputs of more than one EPSRC fellow.

- The 40 spinouts were launched from 2006-2016, over a period of 11 years
- On average 3.6 spinouts were launched per year

Based on Researchfish data, these 40 spinouts are associated with the creation of 57-142 jobs – see Table 13.

Table 13 Number of employees – 40 spinouts linked to the EPSRC fellowships

Number of employees - range	Number of spinouts	Number of employees - lower bound	Number of employees - upper bound
0	16		
1-4	17	17	68
10-19	2	20	38
5-9	4	20	36
[not specified]	*1*		
Grand Total	**40**	**57**	**142**

By means of example, one survey respondent that benefitted from an Early Career Fellowship commented that: "*the research conducted in my fellowship is currently being commercialised through a start-up company, and thus my research output is enjoying considerable impact outside academia. My fellowship was instrumental in allowing me to focus first on research and then on commercialisation/impact activities. It would have been hard to undertake this work with my usual teaching and administration load.*"

Other examples of Fellows that contributed to the launch of a spin-off are presented in Table 14 and Table 15.

Table 14 Evidence from interview – Manufacturing fellowship

2013 (Exeter/Oxford) A key benefit was the ability to move in different directions from the original proposal. This led to him co-founding a company. The idea came about by chance – through discovering a modelling tool at a talk, in a different department, that he attended with one of his postdocs. The modelling tool was freely downloadable and once they 'started trying a few things with it the results were amazing'. Having filed several patents and receiving venture capitalist backing for the spinout, Bodle Technologies was born in 2015. The fellow explained: "What you really learn from commercialisation, particularly a hard [hardware] tech company, is that there are so many cogs in the wheel that need to come together perfectly - the manufacturing, all those things. It's an extraordinarily complex logistical issue as well as being an extraordinarily complex technical issue."

Table 15 Evidence from interview – Postdoctoral fellowship

2011 (Cambridge) Now Lecturer in Chemistry, University of Cambridge The researcher was an applied mathematician when she applied for the Postdoctoral Fellowship towards the end of her doctorate. Before her Fellowship ended she had a Lectureship in Chemistry. Seven years on, she is on secondment leading a research group at Google.

The researcher co-founded a company with two scientists from another and was CSO for the early period of the company's development. She attributes her ability to do this to the Fellowship's terms and conditions.

It is assumed that the GVA of the spinouts created/developed are partially attributable to the EPSRC fellowships. After adjusting for co-funding[10], we find that 85% of the 40 spinouts can be attributed to the EPSRC fellowship programme, which amounts to 33.4 spinouts and, on average, 3.0 spinout per year.

According to the literature[11], university spinouts have 70% higher survival rates than the average start-ups and, as a result of the higher survival rates, the portfolio of spinouts yields a higher than average GVA return. The analysis attributes this higher than average approximate Gross Value Added (aGVA) return to the EPSRC fellowship programmes.

It is also assumed that the spinouts will benefit from 70% higher survival rates for the life of the firm, up to the maximum age 50. The net present value (NPV) of the spinouts at the year of birth, in 2019 prices, is calculated using a 2% discount rate.

Data from the ONS and Eurostat are used to calculate the average aGVA of spinouts, the average number of workers, the average aGVA, and the average survival rate, by firm age.

To estimate the total aGVA of spinouts for the total portfolio of fellowships funded, it is assumed that, on average, 3.0 spinouts were launched per year, in the period 2006-2016.

As presented in Table 16, **the total additional net present value of the spinout aGVA is £317.5m for the period 2004-2019 (14 years)**. This estimate corrects for an impact/reporting lag, as in three of 14 years (2017-2019) in which the EPSRC fellowship was running there were no spinouts recorded. The average additional NPV of the spinout is £7.5m.

Table 16 Estimated additional GVA of spinouts

	Results	**Note to calculations**
Total university spinouts	40.0	
A. Total university spinouts, after correcting for co-funding	33.4	
B. Additional NPV of the spinout GVA at year of birth (2019 prices)	£249,467,378	
C. Average additional NPV of the spinout GVA at year of birth (2019 prices)	£7,461,290	[B / A]
D. Average number of spinouts per year (2007-2018)	3.0	[A / 11 years]
E. Total additional NPV of the spinout GVA at year of birth (2019 prices), correcting for impact/reporting lag	£317,503,936	[D x 14 years x C]

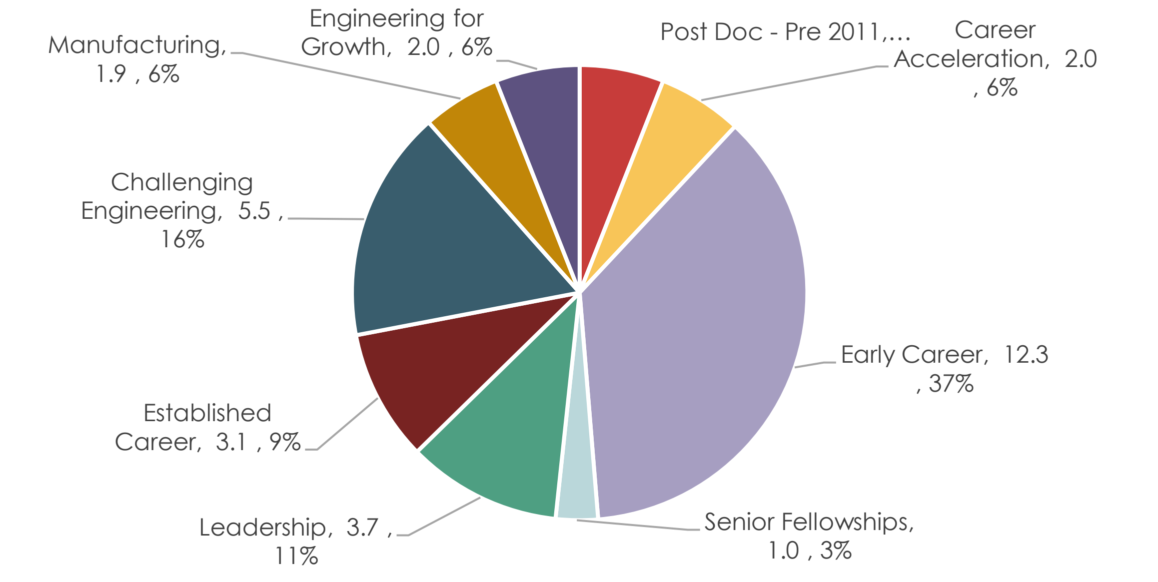
The results by fellowship type are presented in Figure 27, a pie chart showing the percentage of spinouts linked by fellowships type and Figure 28, which illustrates the associated net present value of the spinout aGVA by fellowship type. This shows that a substantial proportion of early career researchers are associated with the launch of a spinout (37% of spinouts), which is estimated to amount to £91.6m in additional GVA. 16% of the spinouts are associated with a

[10] In several cases the university spinout is associated to several grants (beyond the EPSRC fellowships) and the associated value of the spinout that can be attributed to the EPSRC Programme is considered a reflection of the percentage of the EPSRC funding over the total associated grant value.

[11] See Zhang, J. (2009). The performance of university spin-offs: an exploratory analysis using venture capital data. The Journal of Technology Transfer, 34(3), 255-285.

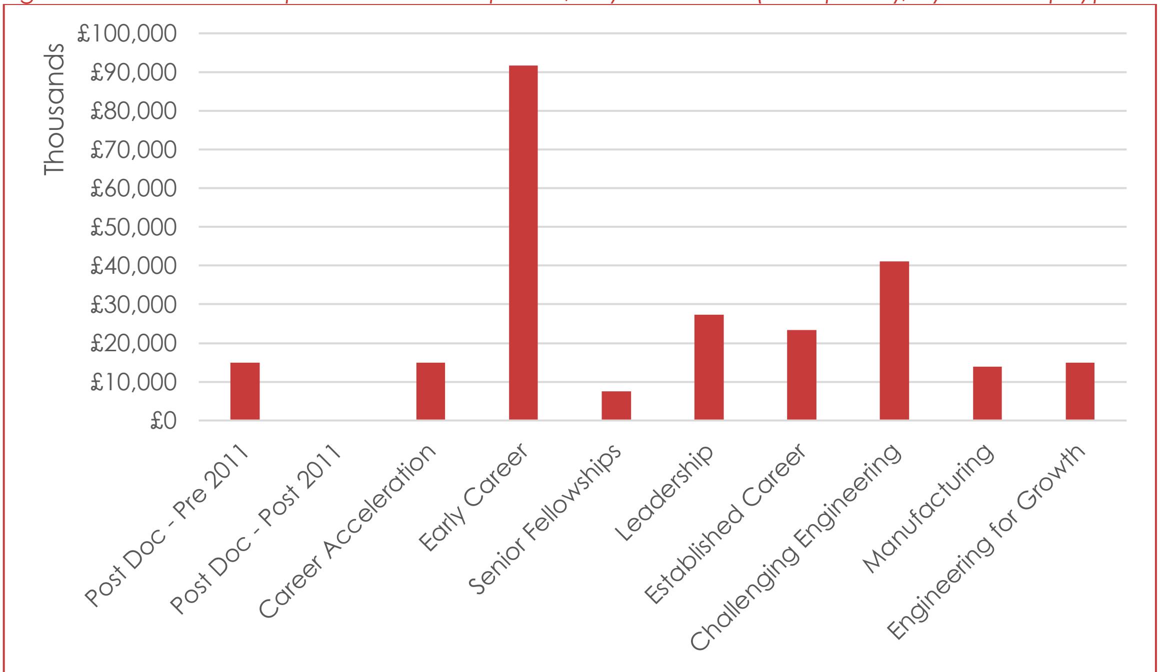
challenging engineering fellowships and these spinouts are estimated to amount to £41.1m in additional GVA.

Figure 27 Total university spinouts, by fellowship type



Note that one spinout benefitted from the input from two EPSRC grants (career acceleration and challenging engineering) and a value of 50% is allocated to each fellowship type.

Figure 28 Additional net present value of spinoffs, at year of birth (2019 prices), by fellowship type



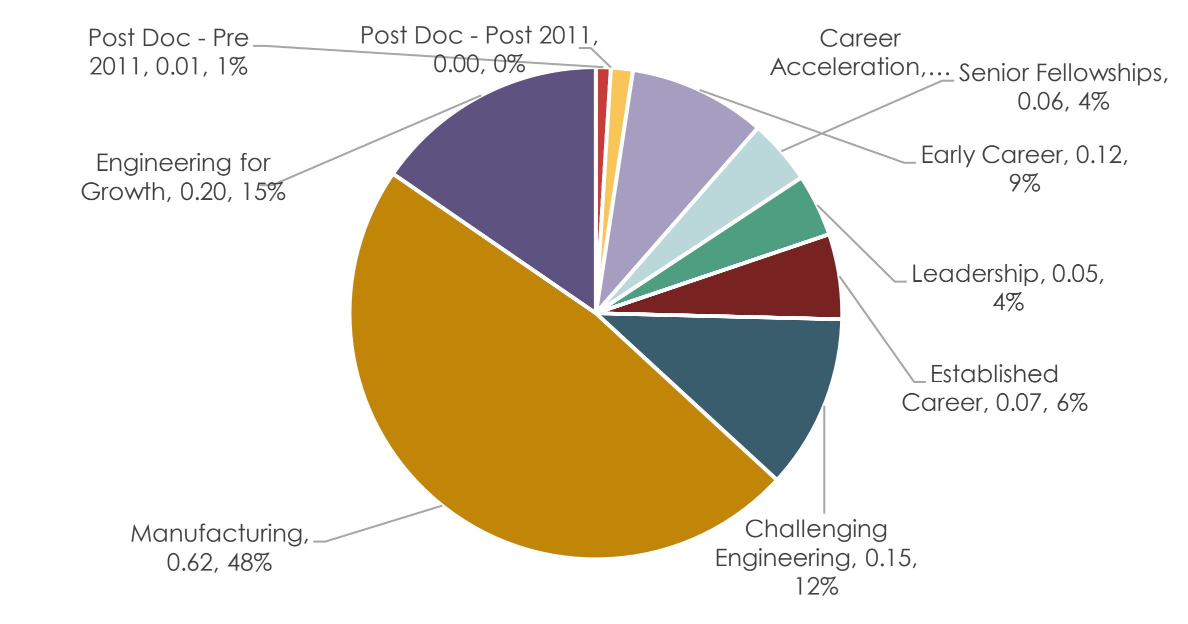
Note that one spinout benefitted from the input from two EPSRC grants (career acceleration and challenging engineering) and the value of the spinout is equally split between the two fellowships.

Table 17 illustrates the probability that a spinout is associated with a given fellowship, accounting for the variation of the number of different types of fellowships granted. Because more than 100 Early Career fellowships were funded, a relatively smaller proportion of these fellowships are associated with the development/launch of a spinout (12%). By contrast, the likelihood of an Engineering for Growth fellowship to result in the development/launch of a spinout is 20%, based on Researchfish data. Figure 29 provides an overview of this comparison by fellowship type, illustrating the strength of the Manufacturing and Engineering for Growth in this regard.

Table 17 Estimated Additional net present value at year of birth (2019 prices) per fellowship funded

	Number of spinouts	**EPSRC proportion (after correcting for co-funding)**	**Additional net present value at year of birth (2019 prices)**	**Number of fellowships**	**Probability of a spinout**	**Value per fellowship**	**Sum of EPSRC grant**	**Value per grant**
Post Doc - Pre 2011	2	2.0	£14,922,580	158	0.01	£94,447	£35,516,705	£0.42
Post Doc - Post 2011	0	0.0		53	0.00	£0	£13,888,120	£0.00
Career Acceleration	2	2.0	£14,922,580	107	0.02	£139,463	£80,110,457	£0.19
Early Career	14	12.3	£91,644,336	105	0.12	£872,803	£76,525,353	£1.20
Senior Fellowships	1	1.0	£7,461,290	18	0.06	£414,516	£12,145,825	£0.61
Leadership	5	3.7	£27,383,035	69	0.05	£396,856	£83,885,064	£0.33
Established Career	4	3.1	£23,286,797	43	0.07	£541,553	£49,529,158	£0.47
Challenging Engineering	8	5.5	£41,051,438	37	0.15	£1,109,498	£34,185,004	£1.20
Manufacturing	2	1.9	£13,872,741	3	0.62	£4,624,247	£3,553,495	£3.90
Engineering for Growth	2	2.0	£14,922,580	10	0.20	£1,492,258	£9,695,519	£1.54
Grand Total	**40**	**33.4**	£249,467,378	603		£413,710	£399,034,700	£0.63

Figure 29 Estimated probability of a spinouts, by fellowship type



Note that the same spinout benefitted from the input from two EPSRC grants (career acceleration and challenging engineering) and a value of 50% is allocated to each fellowship type.

4.2.2 New inventions

EPSRC fellows/alumni have also developed new inventions, and this can be approximated by looking at their patents applications and other intellectual property (IP) protection. As presented in Table 18, 106 patent applications are linked to the EPSRC Fellowships and 35 patents have been granted to date. Those patents are linked to 42 grants in total, including 37 EPSRC Fellowships.

The Researchfish data thus shows that 12% (37/603) of EPSRC fellowships grants are associated with granted patents. The survey evidence shows a slightly more nuanced picture, where 8% (16 of 208 respondents) were in total agreement that the EPSRC Fellowship Programme helped foster the creation of patents, IP or other commercialisation opportunities and another 19% were somewhat in agreement on this.

Figure 30 Survey results - Creation of patents, IP or other commercialisation opportunities (n=208)

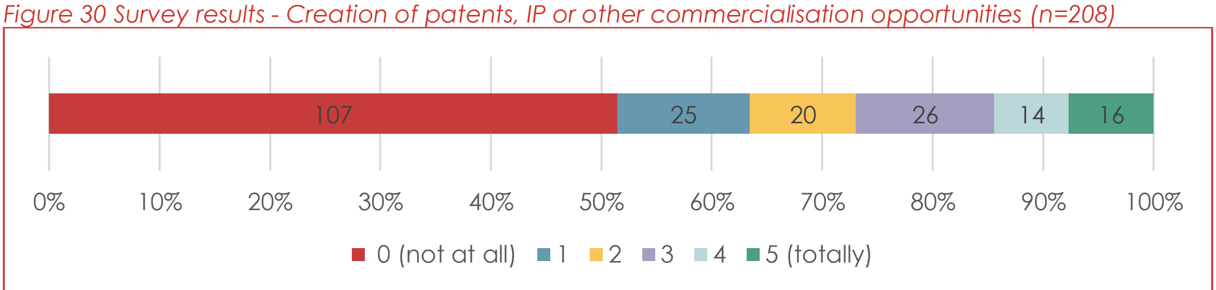


Table 18 Overview of IP linked to the EPSRC fellowships

Type of IP	**count**
Copyrighted (e.g. software)	37
Protection not required	5

Trade Mark	3
Patent applications	106
Granted patents	35

Note that there is a lag between patent applications and granted patents

Table 19 Evidence from interview – Manufacturing fellowship

2013 (Imperial) now Reader in Functional Microwave Materials & Devices, Imperial College London The researcher had worked in industry for fourteen years when he was appointed to a Readership position. News that his Fellowship application was successful came soon after. His Fellowship aim was to focus as much as possible on executing his research vision, to develop better ways of making useful maser devices. This required 'a lot of basic research to get the recipe right'. One collaboration was with a company that services aesthetic lasers. This led to filing a patent around making better optical sources for lasers for beauty treatments. That collaboration got as far as making a successful prototype, but attracting funding for the next stage of development has proven difficult.

Within our modelling, we assume that granted patents will result in a 5% royalty or revenue (e.g. salary) paid to the inventor or university. This royalty is attributed to the EPSRC programme. The 5% royalty/revenue is a margin of the estimated total value of patents[12].

It is assumed that the proportion of EPSRC funding that made the development of patentable solutions possible reflect the value of the EPSRC investment[13],. After adjusting for co-funding, we find that 94% (32.9) of the 35 granted patents are attributable to the EPSRC Fellowships (on average 3.7 per annum between 2007-2015).

The value of the granted patents that are linked to EPSRC Fellowships funding is estimated using data from a survey to UK investors which provides information on the portfolio of patents and its income generation (Patval, 2007). This information allows for us to monetise the value of granted patents, which takes into account the fact that only a small percentage of patents generate income. Based on this data, the average additional value of a patent amounts to £484k.

The combined value of patents (directly produce by fellows or produced thanks in part to publications made by fellow) is estimated to amount to £24.8m. This estimate corrects for an impact/reporting lag because in 5 of 14 years in which the EPSRC fellowship was running no patents were granted that can be linked to the EPSRC Fellowship.

Table 20 Estimated value of patents

	Results	Note to calculations
A. Total number of granted patents, after correcting for co-funding	32.9	
B. Total value of granted patents	£318,559,942	

[12] See also https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/321618/iprpricebooklet.pdf; https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/321618/iprpricebooklet.pdf and https://www.gov.uk/guidance/university-and-business-collaboration-agreements-lambert-toolkit

[13] In several cases granted patents are associated to several grants (beyond the EPSRC fellowships) and the associated value of the patent granted that can be attributed to the EPSRC Programme is considered a reflection of the percentage of the EPSRC funding over the total associated grant value.

C. Average value per patent granted	£9,686,418	[B / C]
D. Additional value	5%	
E. Average value per patent	£484,321	[B x D]
F. Average number of granted patents per year (2007-2015)	3.7	
G. Total additional value of granted patents, correcting for impact/reporting lag	£24,776,884	[G x E x 14]

Figure 31 shows the percentage of granted patents linked by fellowships type and Figure 32 presents the estimated value of the patents. Leadership fellows and career acceleration fellows contributed to 19 patents being granted, 33% and 24% of all granted patents in association with EPSRC fellowship programme. Together these two fellowship programmes are estimated to yield close to £10m in patent premium, 58% of the total estimated value of patents to fellows/university.

Figure 31 Granted patents, by fellowship type

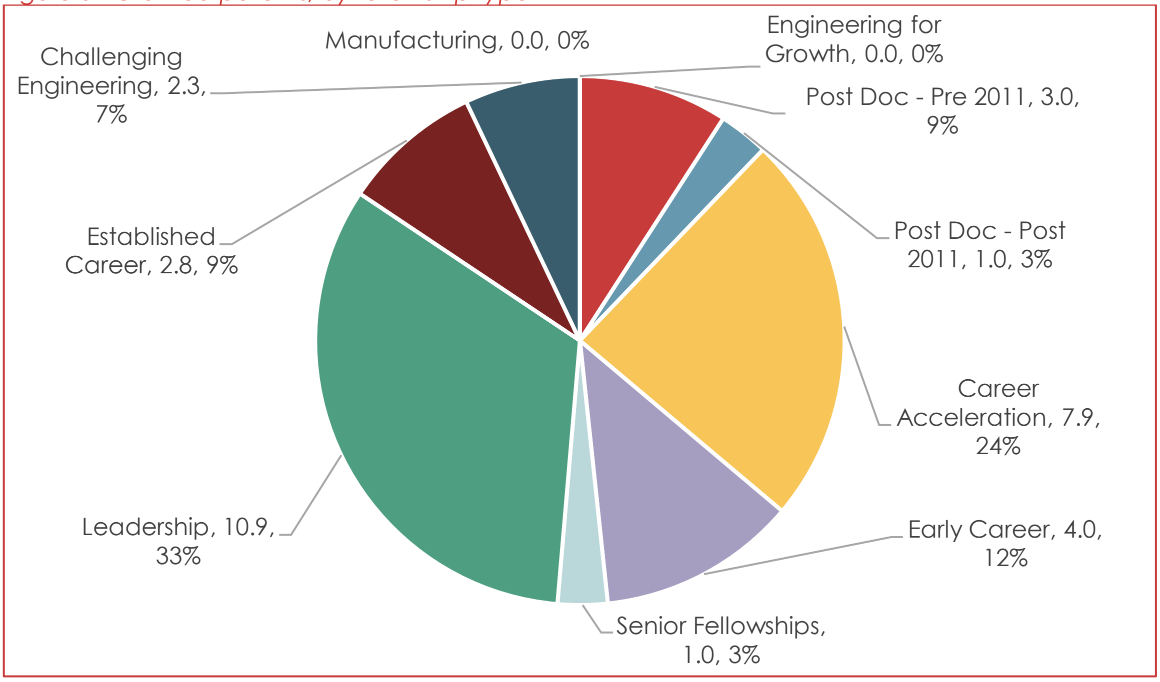


Figure 32 Value of granted patents, by fellowship type

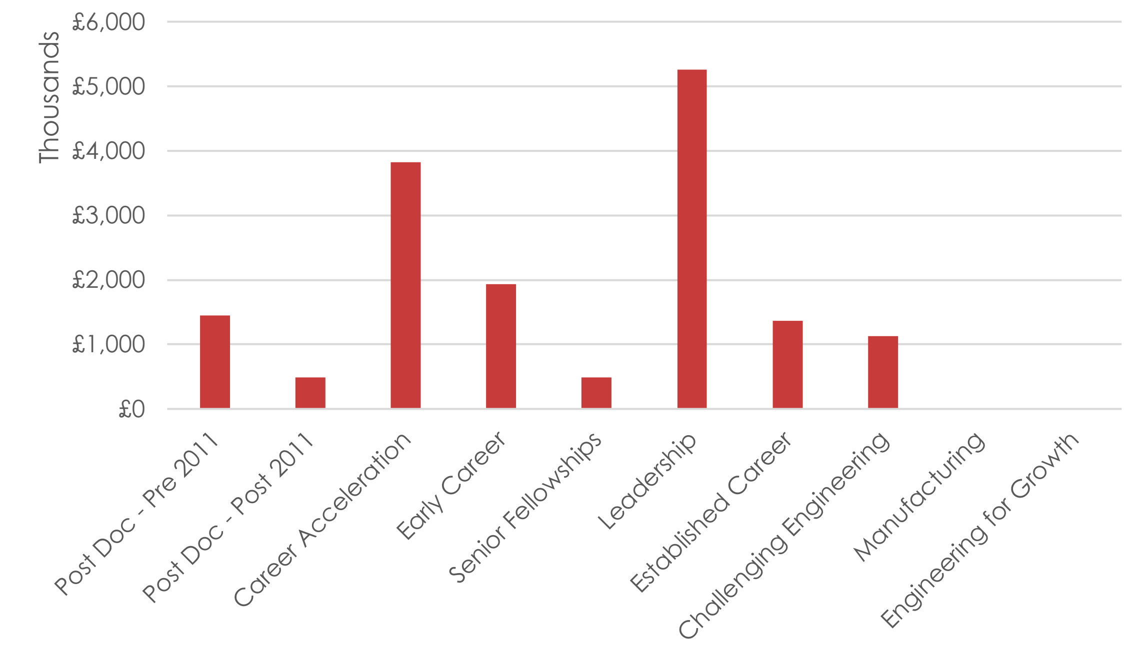


Table 21 illustrates the probability that a patent granted is associated with a given fellowship, accounting for the variation of the number of different types of fellowships granted. The data shows that the likelihood of a fellow being associated with patenting increases with career progression, i.e. it is higher for more established fellows than for post-docs.

Table 21 Estimated value of granted patents per fellowship funded

	Number of granted patents	**EPSRC proportion (after correcting for co-funding)**	**Value of granted patents**	**Number of fellowships**	**Probability of a patent granted**	**Value of granted patents, per fellowship**	**Sum of EPSRC grant**	**Value per grant**
Post Doc – Pre 2011	3	3.0	£1,452,963	158	0.02	£9,196	£35,516,705	£0.04
Post Doc - Post 2011	1	1.0	£484,321	53	0.02	£9,138	£13,888,120	£0.03
Career Acceleration	9	7.9	£3,820,753	107	0.08	£40,234	£80,110,457	£0.05
Early Career	4	4.0	£1,937,284	105	0.04	£18,450	£76,525,353	£0.03
Senior Fellowships	1	1.0	£484,321	18	0.06	£26,907	£12,145,825	£0.04
Leadership	11	10.9	£5,260,533	69	0.16	£76,240	£83,885,064	£0.06
Established Career	3	2.8	£1,362,508	43	0.07	£31,686	£49,529,158	£0.03
Challenging Engineering	4	2.3	£1,125,314	37	0.06	£30,414	£34,185,004	£0.03
Manufacturing	0	0.0	£0	3	0.00	£0	£3,553,495	£0.00

Engineering for Growth	0	0.0	£0	10	0.00	£0	£9,695,519	£0.00
Grand Total	**35***	**33.9**	**£15,927,997**	**603**		**£32,528**	**£399,034,700**	**£0.04**

Note: *One patent benefited from multiple EPSRC Fellowship grants: allocation corresponding to funding proportion

Table 22 below showcases an outstanding example of innovation supported by the fellowships, in the area of bespoke characterisation instruments.

Other examples provided via survey include the development of devices for emerging quantum technologies, with potential impact in computing, communication and sensing, and contributions to improving standards for engineering safety.

Table 22 ArC Instruments

ArC Instruments Limited is a good example of successful spin-off activity from an EPSRC fellowship. The ArC product range is based on concepts developed by Professor Themi Prodromakis (University of Southampton) during his Early Career Fellowship grant. The work was further developed by Professor Prodromakis and colleagues who set up the company in 2015.

ArC provides innovative solutions in the field of electronics. In particular, it provides novel testing solutions that allow for large-scale testing and interfacing with thousands of components simultaneously, thus accelerating R&D of electronic technologies. Consequently, ArC Instruments is attracting customers worldwide including

- Academic research groups
- Multinational companies, such as Toshiba and Huawei, that make use of instruments for their R&D
- Standards institutes, such as the National Institute of Standards and Technology in the US

ArC tools can also be used in teaching and training. In fact, a number of research institutes around the world have introduced ArC instruments into their curricula and have used ArC instruments as novel demonstrative tools. It has also made ArC software open source, allowing other researchers to use and share the software to develop their own testing routines.

ArC also continues to expand its product range. For instance, a general-purpose testing platform that is able to control thousands of individual devices simultaneously has been developed recently for researchers who want to emulate artificial neural networks (for AI) that read and write data in parallel.

Demand for ArC products and continuing R&D activity has led to the creation of new jobs as well as work placements for University of Southampton staff and students. In addition, state-of-the-art technology is now at the disposal of research staff, resulting in synergic research collaborations. Altogether, ArC has had a massive impact on the electronics industry and the wider R&D ecosystem around the development and use of memristor (a type of electronic memory device) technologies and related products. The magnitude of this impact is such that it is likely to be showcased as a case study in the next Research Excellence Framework.

4.2.3 *Knowledge flows (spillovers)*

EPSRC fellows' scientific research can contribute to the development of new technologies developed by other researchers/innovators. This can be investigated by looking at the co-authoring of papers with industry, and the uptake of knowledge by industry via citations in publications and patents. There is also evidence of wider uptake from academics, industry and policymakers.

4.2.3.1 Co-authoring and citing publications

The EPSRC Fellowships is enabling researcher to work with the private sector and is contributing positive impact on the innovation landscape. The bibliometric analysis shows that:

- 9% (1,003 of 11,775) of papers are co-authored by the private sector
- 42% (4,964 of 11,775) of papers are cited by the private sector
- 19,904 citations are from the private sector (1.69 per paper)

Figure 33 Impact of the EPSRC fellowship on the private sector

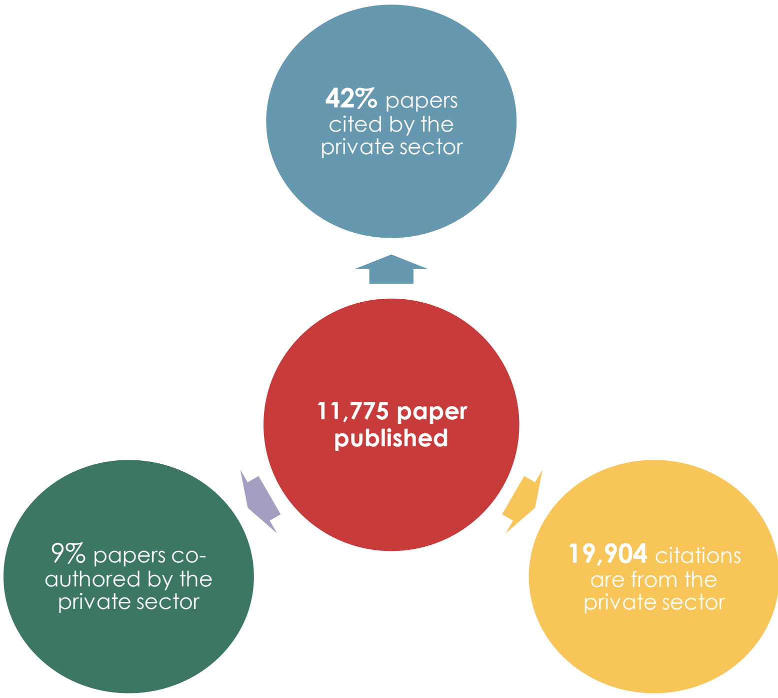


Figure 34 shows how papers published by EPSRC fellows have been cited in other papers in which at least one author was affiliated to the private sector. though not a direct measure of private sector influence, it does provide a useful proxy and provides an indication which fellowships are more closely linked to the private sector. Research produced by the more established fellows and those taking a targeted fellowship programme are shown to be particularly relevant to the private sector. 57% of the total RC papers published by Manufacturing fellows are cited by the private sector and 53% of the papers published by Challenging engineering fellows are cited by the private sector.

Pre-2011 Post-Doctoral fellows had 369 papers cited by the private sector (38% of total RC papers published by those fellows), whereas post-2011 fellows had 142 papers cited by the private sector (27%). It could be argued that the total is lower for post-2011 fellows as there are less of them compared to pre-2011 (53 to 158), however pre-2011 fellows also have a higher proportion of their total papers cited by the private sector. We see a similar result in the second chart showing the number of citations in total and per paper. Both fall below the average citation per paper across all fellowships, more so for post-2011 fellows. Again, these results might be expected from early career researchers and are still encouraging. They show post-doctoral fellows are being recognised and feeding into industry even at this early stage.

Figure 34 Papers cited by the private sector, by Fellowship type

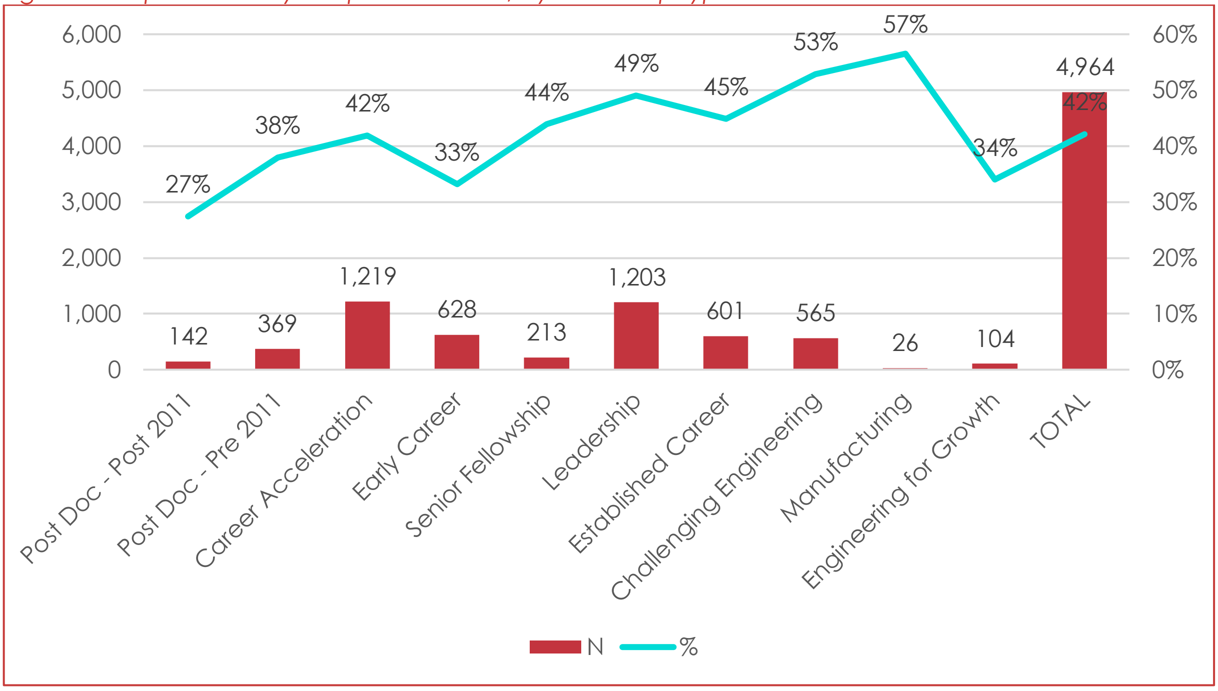


Figure 35 Number of citations from the private sector, by Fellowship type

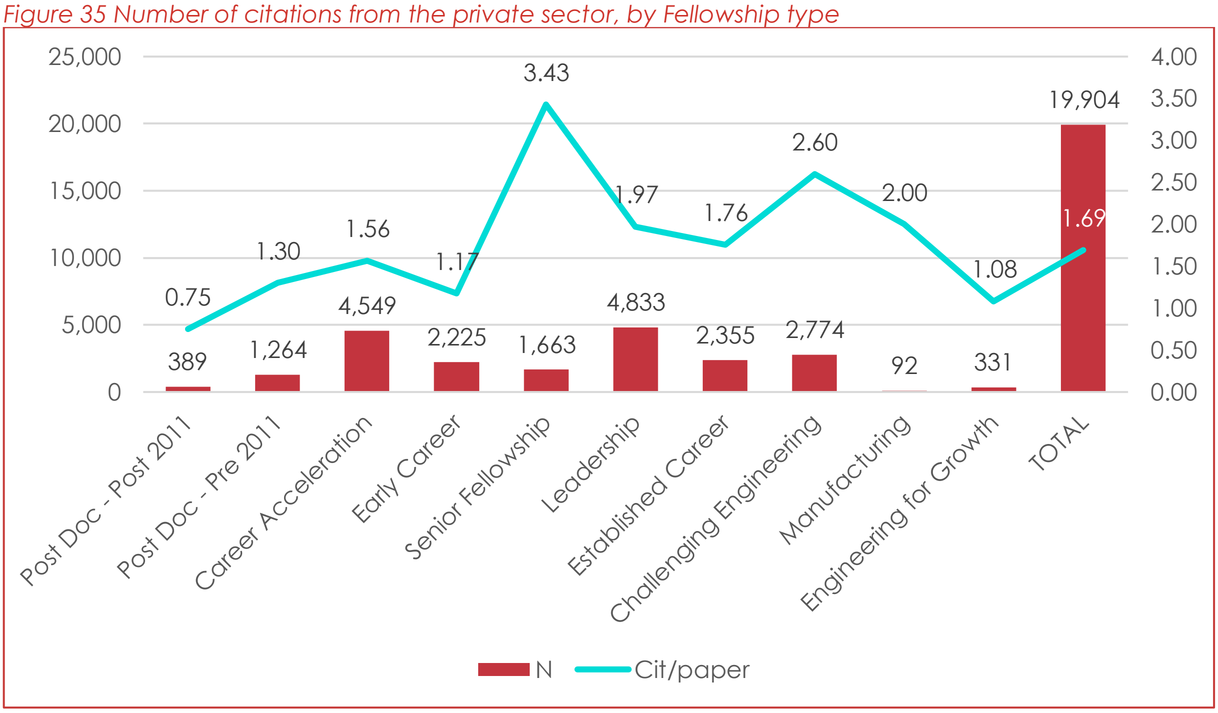
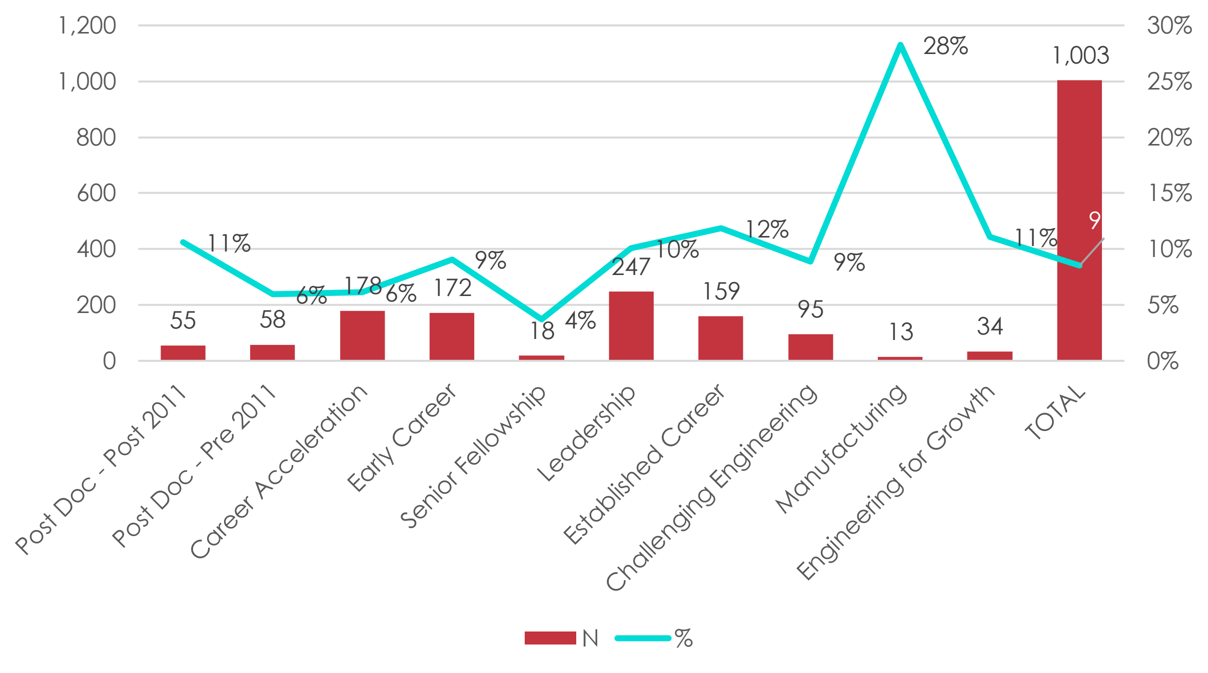


Figure 36 and Figure 37 provide a more direct measure of industry engagement by measuring co-authorship and citations in patents, by Fellowship type. Co-authorship[14] activity varies by Fellowship type, with Manufacturing fellows, small in number, being a bit of an outlier with 28% co-authorship. Senior fellows seem to interact less with industry, with only 4% interacting with

[14] Number of papers with at least two authors in which at least one author is affiliated with the private sector.

industry. Pre- and post-2011 Post-Doctoral fellows both show moderate co-authorship activity. Co-authorship as a percentage of all RC papers was particularly high for Post-2011 fellows, potentially showing a higher level of collaboration for this cohort overall than for the pre-2011 cohort.

Figure 36 Co-authorship with private sector, by Fellowship type



4.3 Citations in patents

Knowledge produced by the fellows could also have been used as building blocks for innovations generated by other inventors. This information is traced by exploring the non-patent literature of granted patents worldwide. Patent documents offer a valuable paper trail of knowledge flows as inventors are required to reference the predecessors of new inventions. Such references are added to patent applications to reflect the prior art that inventions have built upon. Besides citing earlier patents, other non-patent material is also cited ('non-patent literature'), including frontier scientific knowledge that sets the boundaries of patents' claims for novelty, inventive activity and industrial applicability. Examples of non-patent literature include peer-reviewed scientific papers, conference proceedings, or databases. Patents that cite scientific references often contain more complex and fundamental knowledge that in turn makes these patents significantly more valuable than patents that do not cite scientific literature.[15]

The estimated benefit of the 'knowledge transfer' and/or technology or product innovation spillovers is captured using data to estimate the value of the patents that have cited fellows' publications. It should be noted that these spillover benefits will accrue to UK and non-UK based innovators.

[15] OECD (2013), "Measuring Patent Quality: Indicators of Technological and Economic Value", OECD Science, Technology and Industry Working Papers, No. 2013/03, OECD Publishing, Paris, https://doi.org/10.1787/5k4522wkw1r8-en.

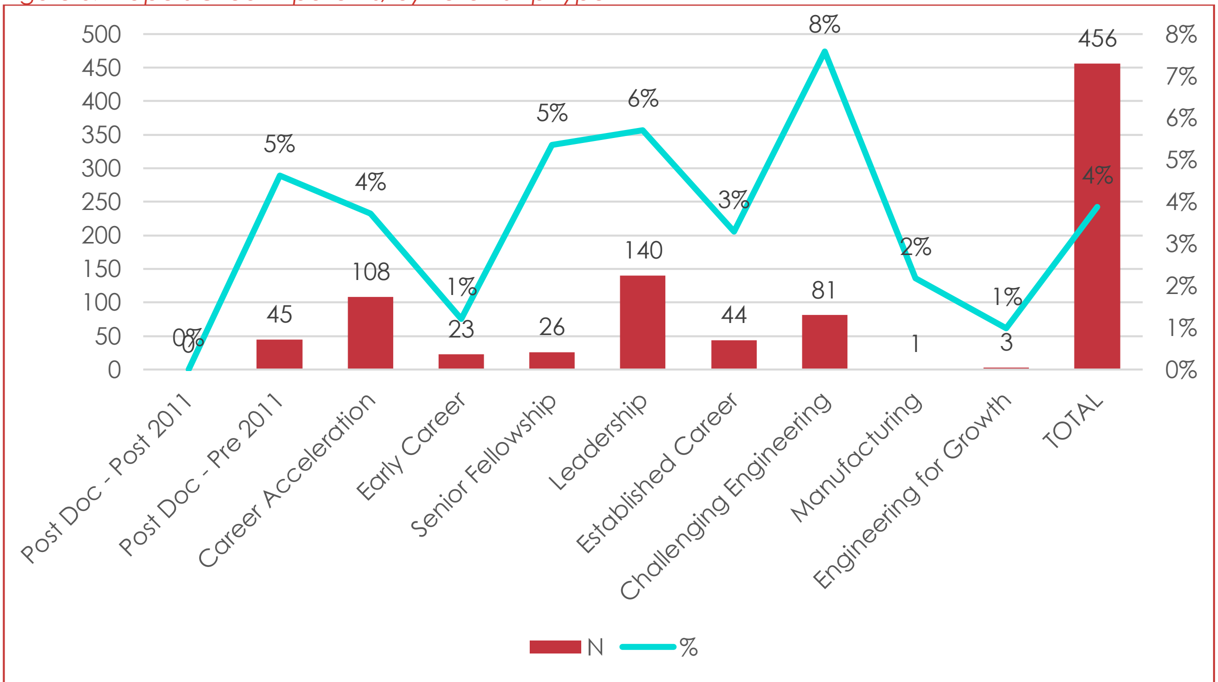
Table 23 Evidence from interview – Established career fellow

2013 (Bath/Bristol) Now Professor of Statistical Science, University of Bristol
'Like most statisticians', the fellow did not know much about the high-performance computing needed for big data methods, and the Fellowship enabled him to learn a lot more about this in order to make a useful contribution, through academic papers and developing open source software.
"That has taken off; that work gets used quite a lot in industry. The most extraordinary one is the US farmers' business network that uses these methods because of the computational efficiency to develop tools for advising farmers on how to maximise inputs to maximise outputs."
The network has told the researcher that 0.6 billion dollars' worth of improvements for the farming sector has happened off the back of this improved efficiency. *"They probably found out about these methods from the open source software and then went back and looked at the academic papers."*

Based on data from Researchfish and 'Lens', there are 414 publications that can be attributed to the EPSRC fellowship that are referenced by 1,012 patents. Data from a survey to UK investors (Patval, 2007) is used to estimate the value of the portfolio of patents. The approach to monetise the value of granted patents takes into account the distribution of a portfolio of patents.

The bibliometric analysis enabled identifying scientific production for an additional 18 fellows through a tracing of funding acknowledgements. As a result of this tracing, it was found that 456 papers in total are cited by patents, i.e. close to 4% (456 of 11,775) of papers – see Figure 37. Data for the 42 additional publications cited by patents are not considered in the economic modelling, contributing to make the estimated economic impact conservative.

Figure 37 Papers cited in patents, by Fellowship type



The estimated value of the portfolio of patents that can be attributed to the EPSRC fellowship is a factor of the median number of Non-Patent-Literature (NPL) citations of the portfolio of patents, which is 27. 3.7% of the patent value is attributed to a publication linked to the EPSRC Fellowship, after correcting for co-funding. Based on this data, the average additional value of patent amounts to £358.8k.

The proportion of EPSRC funding that made the publication outputs possible reflect the attribution of the EPSRC investment. After adjusting for co-funding, the 1,012 patent number is reduced to 855.7.

To estimate the total spillover effect for the total portfolio of research funded, it is assumed that for 2006-2019, on average, 99 patents cite publications that are linked to the EPSRC Fellowship, adding £358.8k in additional value per patent. In 6 of 14 years in which the EPSRC fellowship was running the number of patents that cited publications that are linked to the EPSRC Fellowship is relatively low or zero. Between 2008-2015, on average 99 patents cited publications that are linked to the EPSRC Fellowship. **The total additional value of granted patents, correcting for impact/reporting lag is estimated to amount to £477.5m** see also Table 24.

Table 24 Estimated spillovers due to Technology / product innovation spillovers

	Results	**Note to calculations**
A. Total number of granted patents, after correcting for co-funding	855.7	
B. Total value of granted patents	£8,288,314,985	
C. Average value per granted patent	£ 9,686,418	[B / C]
D. Median number of NPL per granted patent	27	
E. Average additional value per granted patent	£358,756	[C / D]
F. Average number of granted patents per year (2008-2015)	99	
G. Total additional value of granted patents, correcting for impact/reporting lag	£477,516,090	[F x E x 14]

Figure 31 shows the percentage of granted patents that cite publications of EPSRC fellows, linked by fellowships type. The publication linked to leadership fellows and career acceleration fellows appear to yield a higher volume of citations in patents. Figure 32 presents the estimated value of the patents, in relation to the EPSRC fellowships, i.e. £82.18m and £76.1m are linked to leadership fellows and career acceleration fellows.

Figure 38 Granted patents, by fellowship type

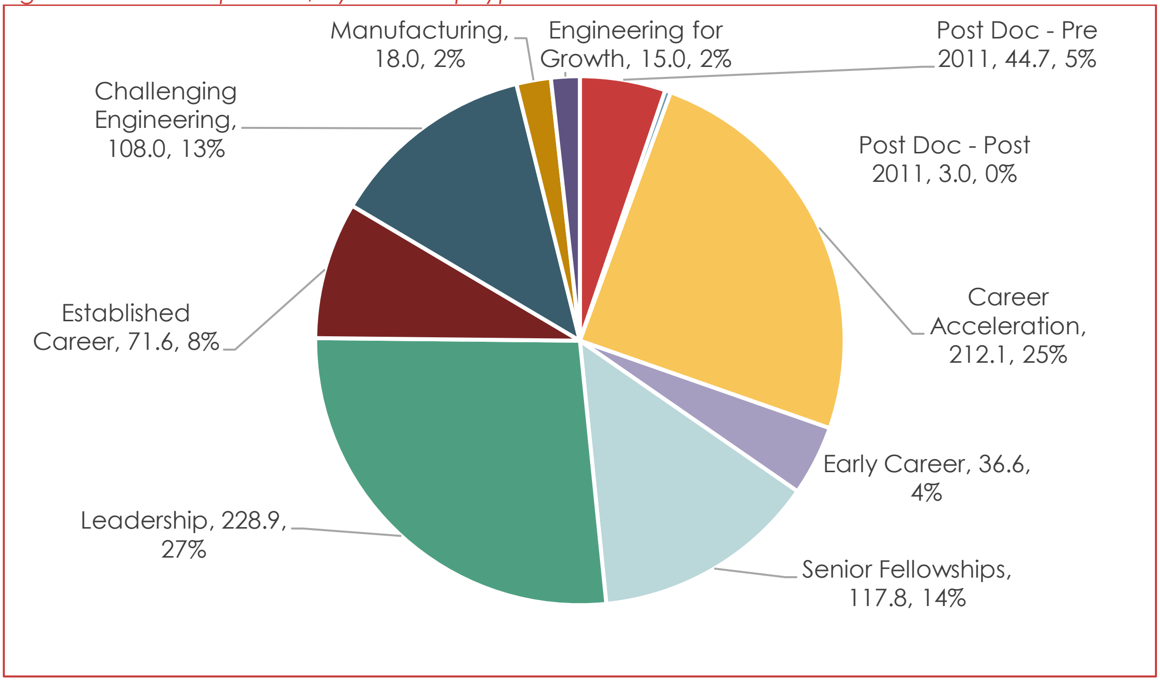
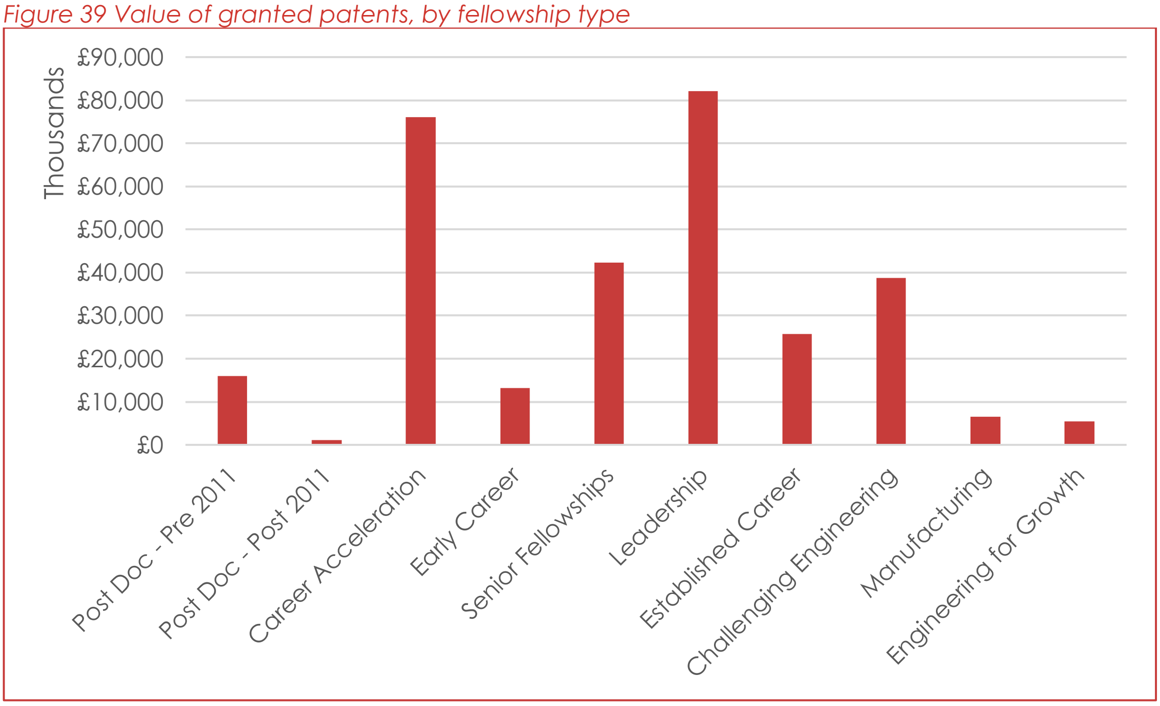


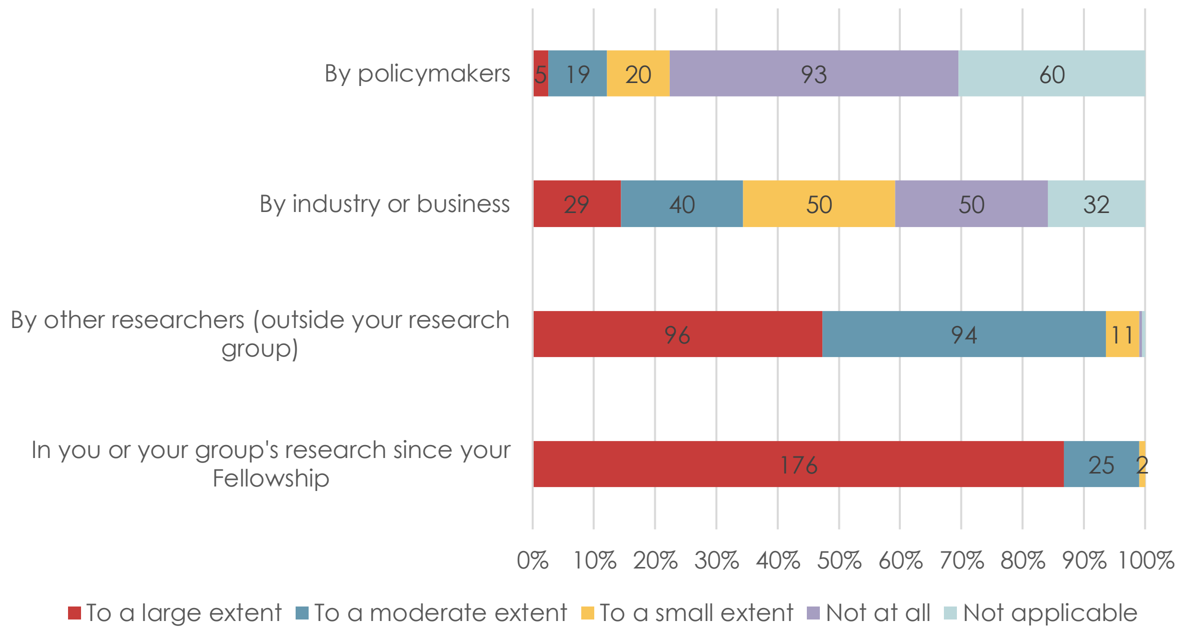
Figure 39 Value of granted patents, by fellowship type



4.3.1.1 Wider uptake of knowledge

Survey respondents were invited to indicate to what extent the outcomes from their research (and/or advances in knowledge achieved) were subsequently used. As presented by means of Figure 40, the vast majority of respondents suggest that research outcomes have subsequently been used by the researcher and/or the researchers' research group (which has already been investigated in Section 3.3.2 via an analysis of citation impact). Also, research outcomes have been used, at least to a moderate extent by researchers outside of the fellows' research group, in the majority of cases. **The majority (59%) of respondents suggest their research has been used, at least to some extent, by industry and business and 22% suggest it has been used, at least to some extent, by policymakers.**

Figure 40 Extent to which outcomes from fellowships have been used subsequently (N=203)



Note: Number of respondents to sub-questions are reported in the figure

4.3.2 Further dissemination of results

Finally, advocacy is part and parcel of activities undertaken by researchers including EPSRC fellows. It can include STEM outreach and public engagement; promotion of responsible research as well as equality, diversity and inclusion in research; communicating research knowledge and expertise with policymakers to allow evidence-based policy making; and engagement with industry to facilitate collaboration, investment and/or new product development. Advocacy is accomplished through a variety of dissemination and engagement activities with diverse audiences from the general public and school audiences all the way to researchers, industry and policy makers.

Out of 603 fellowship grants commenced between 2006 and 2018, 2549 dissemination and 116 policy engagement activities were reported for 247 and 61 grants respectively in Researchfish. Presentations or talks accounted for 45% (n=2549) of all dissemination activities and were reported for 30% (n=603) of all fellowship grants. These led to outcomes and impacts in research, economic and regulatory domains.

4.4 Wider impact

4.4.1 Impact to society at large

EPSRC Fellowship alumni (survey respondents) were asked to indicate in which areas their research contributed. The results (see Table 25) suggest that the majority of respondents find that their research is contributing to generate economic impact.

Close to a third of respondents find that their research is contributing to make a health impact, a social impact and/or an environmental impact. To exemplify the health impact, one respondent indicates that the research contributed to the development of new imaging methods that have been taken up by MRI scanner vendors and another commented that the research had helped develop a new method to predict protein structure and yet a third commented that the research had helped develop imaging techniques for neurology and cancer diagnosis and monitoring. The research was also commented to have helped secure the supply of safe drinking water from ageing infrastructure. In terms of environmental impact. One alumnus commented that the research conducted contributed to new industrial collaborations on solar energy. Examples of social impact include public engagement, science education, collaboration with museums, writers, composers and public engagement professionals to read large audiences

Around 23% of respondents find that their research is contributing to generate an impact on quality of life, and even fewer find that it is contributing to make a difference to public policy or services. One alumnus commented that he/she "*worked with Electricity North West to deliver a decision-making tool which to date has saved £5 million for customers*." Another alumnus indicated that his/her research is used regularly for policy analysis at the European Commission and is expected to be used by UK government. Few alumni indicated that their research *only* contributed to quality of life. One alumnus, that did indicate a positive impact in this direction noted that the research is in fundamental mathematics and, although it may transform society in profound ways, "*when and how it might do so is difficult to predict*".

Table 25 Wider impact of fellows' research (multiple responses possible, N=124)

	Responses	**Percentage of respondents**
Economic impact	84	68%
Health impact	37	30%
Social impact	36	29%
Environmental impact	36	29%
Impact on quality of life	28	23%
Public policy or services	11	9%

Table 26 Evidence from interview – Early Career fellowship

2013 (Manchester, QMUL). Now Professor of Mathematics, QMUL

The researcher applied for the Fellowship because he saw it would provide the opportunity to 'essentially try to establish a new [research] area or at least set a new agenda'. This was the interface between applied probability and power systems engineering. The researcher could see a clear opportunity, but also that would take significant investment in time. "Knowing about the Fellowships and the fact they offered up to 100% buyout of time for your research it seemed to me to be essentially the only way I could realise that".

Collaboration with the researcher's original power systems colleague at Manchester and Electricity North West led to the development of a software tool that the company has, to date, used to improve 14 investment decisions, yielding an estimated saving of £5m. A joint research paper written with the company is one of the research impacts the researcher is most proud of. It was picked up by National Grid and recommended as a best practice implementation of Network Options Assessment

Table 27 Evidence from interview – Established Career fellowship

2013 (Sheffield), Professor of Mechanical Engineering, University of Sheffield

The researcher has pursued Fellowship funding throughout his career to provide control and flexibility to pursue research. He previously held an EPSRC Advanced Fellowship, which was 'absolutely pivotal' to his subsequent career, supporting subsequent grant applications and promotion to Chair.

The fellowship has led to involvement in an EPSRC Prosperity Partnership with Siemens Gamesa. This project's origins in the machines and drives group in the electrical engineering department broadened to include the dynamics group when the two departments and Siemens Gamesa saw scope for building on their existing relationships jointly.

"A lot of the activities we put forward in the Prosperity Partnership [proposal] were being generated by ideas from the original Fellowship".

"Prosperity Partnerships target Technology Readiness Levels 1-3, so industrial impact is some way off, but ultimately, this work on 'the health and condition monitoring of offshore wind turbines is a way of driving down the cost from renewables'."

Data from Researchfish corroborates some of these findings. 326 EPSRC fellows provide a narrative statement and 367 narrative statements are provided in total. The impact is flagged by a number of these fellows as providing economic value (93) providing cultural value (33), providing societal value (23), providing value to policy & public services (9) or a combination thereof (130). For example, one career acceleration fellow reported that the research findings "are now being used by Pharmaceutical companies to improve the shelf-life of a range of preparations" (Researchfish).

For 306 entries an 'audience' is specified, which references, amongst other, the following sectors: Digital/Communication/Information Technologies (93 entries); Healthcare (78); Energy (75); Education (71); Aerospace, Defence and Marine (50); Chemicals (48); Creative Economy (16); and Agriculture, Food and Drink (15).

Table 28 Evidence from interview – Challenging engineering

2009 (Leeds) Now Professor of Environmental Engineering for Buildings, University of Leeds

"The project I'm working on now is a direct result of Challenging Engineering. It's called a health impact partnership (HIP) and to be eligible you have to have previous EPSRC money in 'the health space'. Two primary outcomes from the Fellowship are the primary underpinning methodologies for the HIP grant. The theme of the Challenging Engineering award was 'hospital ward design to integrate the energy, comfort, and infection transmission [control]. The current HIP project[16] builds on how you use those methodologies and take those into practice and how you then develop a model for doing 'real time air-flow management' in buildings... There's a second aspect to the HIP which is very exciting, which came about through one of the smaller elements of Challenging Engineering, a PhD project which turned into 'a key thing we do'. It's a model for modelling contamination of hospital workers' hands from touching hospital surfaces. The principle of that study, 'the micro-scale modelling of infection transmission', is one of the core things in the HIP grant, and is now also underpinning work on the COVID-19 response. We're now working with people in Arizona and Ohio and across the UK to build those transmission models up through different mechanisms for hospital environments and also transmission in other environments such as transport."

Table 29 Extract from narrative statement of a career acceleration fellow (data from Researchfish)

The impact on my career of the fellowship has been enormous. The freedom afforded by a fellowship has enabled me to develop my own team, and extend my research activity and its reach internationally - far beyond my original expectations.

- My research has been used to inform the London Spatial Development Plan to be more 'climate sensitive' to enhance resilience to extreme events and consider climate risks in long term planning.
- My work on integrated assessment of cities has been picked up and are starting to be applied internationally in Durban, Shanghai and several European cities.
- Work on coastal infrastructure management won an insurance industry award, but has also been used by the UK's Committee on Climate Change.
- A new type of socio-technical modelling approach has been applied in North Wales to help inform the local evacuation strategy in the case of a coastal flood.

- The work has been heavily cited in the IPCC's 4th and 5th assessment reports which inform international climate policy.
- My research has been recognised internationally through appointment to the Future Earth Cities Theme Leadership Group and the Steering Group of the international Urban Climate Change Research Network

Career Acceleration Fellow

4.4.2 Other unanticipated impacts

Finally, 31% of survey respondents (60 of 192) suggest that there have been unanticipated impacts / relevance of the research conducted during their fellowship. A variety of unanticipated impacts were reported including:

- Research advancements and unanticipated changes in research direction
- Involvement in other research projects and or research in unexpected areas and follow-on collaborations, including with industry and/or other academic groups
- Training of support staff and practitioners, including from local government services
- Recognition of research by professional bodies and/or government
- Media attention to research outcomes and collaboration, including with museums, writers, composers and public engagement professionals
- The development of more non-academic impact than anticipated and impact on industry such as the adoption of technology and/or solutions developed
- Application of outcomes to sectors that had not been anticipated and interest from industry in different application areas (including cybersecurity)
- Application of outcomes to disciplines and contexts that had not been anticipated (e.g. archaeology and forensics)

One survey respondent provided a more specific example of an unanticipated impact and noted the following "When Pee Power was first trialled at a girls' boarding school in sub-Saharan Africa, we did not anticipate that the lighting at night (powered by the generated bio-electricity) would actually prevent attacks on the girls at night, either from male intruders or predatory animals".

5 Economic assessment of impact

5.1 Scope of the analysis

The Return on Investment (RoI) of the EPSRC Fellowship Programme consists of an assessment of its costs and (monetised) benefits. This analysis draws a comparison between investments made in fellowships funded in the period of 2005-2018 and the impact this has generated so far and is expected to generate in the foreseeable future.

The EPSRC Fellowships generates benefits via different routes as already covered in the prior sections. The funding provides researchers freedom to pursue their research interests and provides them with recognition and prestige, which is then associated with the work they produce during and after the fellowship. The level and duration of funding also enables them to take more risks in terms of their research objectives, allowing them to produce both more and better-quality work. This could in turn lead to new and disruptive knowledge and innovations that benefit the wider society. Fellows also have a role to play in terms of mentorship and in support of the next generation of researchers.

In a RoI analysis benefits are converted into monetised units. This means, in practice, finding good approximations to translate those benefits into pounds, understanding that in many cases they materialise into tangible and intangible results that are difficult to express in monetary values. The modelling includes an estimation of the impact on the researcher's career and the impact on knowledge and innovation.

5.2 Estimated total benefits

The RoI follows the methodological guidelines of Sartori et al. (2014) — Guide to CBA of Investment Projects — in respect to investments in research, development and innovation.[17] All the benefits included in the RoI are based on these guidelines with adapted data sources and parameters to reflect the reality of the EPSRC fellowship programme. The four channels of impact under consideration are:

- **Career progression: Wage premium.** The estimated value of the wage premium earned by EPSRC fellowship alumni, over their career, due to their participation in the programme. This provides a proxy of the effect of the programme in accelerating the fellows' careers. As specified in Sartori et al. (2014), the premium is the incremental lifelong salary earned by researchers over their entire work career. The increment is in comparison to a scenario where the researchers/fellows would not have been granted the EPSRC fellowship. The assumed wage premium in this analysis was of 1.04 %, based on self-reported values from the survey of alumni conducted in the context of this study.
- **Knowledge and innovation (direct effects): Additional value of spinouts.** The estimated additional value of spinouts (turnover) that were created by EPSRC fellows/alumni. The methodology suggested in Sartori et al. (2014) to measure the additionally of spinouts is to assess how the programme contributes towards increasing the survival rate of start-ups. The benefit being measured is the Gross Value Added (GVA) attained by university spinouts created by EPSRC fellows, which are assumed to survive longer than 'regular' start-ups in a without-the-programme scenario. Under the counterfactual scenario where EPSRC university spinouts would not exist, 'regular' start-ups could have access to more financial and other types of resources. Spinout additionality resulted from the assumption that

[17] Sartori, D., Catalano, G., Genco, M., Pancotti, C., Sirtori, E., Vignetti, S., & Del Bo, C. (2014). Guide to cost-benefit analysis of investment projects. Economic appraisal tool for Cohesion Policy, 2020.

university spinouts have 70% higher survival rates than regular start-ups and this assumption has been subjected to a sensitivity analysis (see Appendix). The initial assumption (of 70%) is based on the scientific literature showing that university spinouts have approximately 50% to 90% higher survival rates than other start-ups.[18]

Knowledge and innovation (direct effects): Additional value of granted patents. The estimated additional value of granted patents that are linked to the EPSRC fellows/alumni. Sartori et al. (2014) suggest that there is an additional value emerging from patents associated to new or improved technologies developed in the context of a research programme. The model captures the additional value attained by patents linked to developments supported by the programme (and by the EPSRC fellows), in comparison with 'regular' patents. To arrive to an estimate of additional value it is assumed that 'university patents' are 5% more valuable than 'regular' patents and this assumption has been put subject to a sensitivity analysis. The initial level of 5% is a conservative assumption based on findings from the scientific literature showing that 'university patents' have a substantially larger number of citations than non-university patents (60% more citations), and that patent citations are associated with higher economic value (an additional 3% in firm valuation for each additional citation). [19]

- **Knowledge and innovation (spillover effects): Additional value of granted patents to other stakeholders.** The estimated additional value of granted patents to other stakeholders (beyond EPSRC fellows/alumni), which draw on knowledge (publications) produced by EPSRC fellows/alumni. Sartori et al. (2014) suggest that 'knowledge spillovers' to non-direct beneficiaries can be counted as benefits in a CBA. In the context of this analysis, knowledge spillovers are captured as the knowledge embedded in publications from EPSRC fellowships and used in patents owned by other stakeholders (tracked through non-patent literature citations). A minor part of these patents' value is attributed to the EPSRC, based on the finding that patents citing academic publications are of significantly higher quality than patents that do not.[20] The median value of non-patent literature citations of others stakeholders' patents citing EPSRC knowledge is 27, and it is therefore assumed that 3.7% of these patents' value is attributed to the EPSRC publication. This value has been put subject to a sensitivity testing.

A robust RoI assessment needs to consider displacement, substitutions and deadweight effects. In terms of displacement, two effects were considered. First, EPSRC fellows are given an opportunity to boost their careers which would make them more competitive candidates for other/future grants, enabling them to source additional funding and possibly displacing other researchers competing for the same opportunities — a displacement effect. Monitoring data on the total number of applications, and the total number invited to the final stage of application is used to calculate success rates and displacement rates. It is assumed that the percentage of EPSRC Fellowship applicants that are rejected after the interview round are potentially displaced. Based on these figures, the rate of displacement is assumed to be 49%. Second, the time and effort of unsuccessful applicants in applying for the EPSRC is also a

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[18] Zhang, J. (2009). The performance of university spin-offs: an exploratory analysis using venture capital data. The Journal of Technology Transfer, 34(3), 255-285.

[19] Manuel Trajtenberg, Rebecca Henderson & Adam Jaffe (1997) University Versus Corporate Patents: A Window On The Basicness Of Invention, Economics of Innovation and New Technology, 5:1, 19-50, DOI: 10.1080/10438599700000006 and Hall, B., Jaffe, A., & Trajtenberg, M. (2005). Market Value and Patent Citations. The RAND Journal of Economics, 36(1), 16-38.

[20] OECD (2013), 'Measuring Patent Quality: Indicators of Technological and Economic Value', OECD Science, Technology and Industry Working Papers, No. 2013/03, OECD Publishing, Paris, https://doi.org/10.1787/5k4522wkw1r8-en and Branstetter, L. (2005). Exploring the link between academic science and industrial innovation. Annales d'Economie et de Statistique, 119-142.

displacement effect. From the 2,425 applicants, 1,822 were not successful. Average salaries by age bracket were used to place a cost on the time and effort spent by unsuccessful applicants. It was assumed that the application process involves five days of work per applicant and 261 working days per year. The total cost of time and effort spent by unsuccessful applicants is assumed to be £1.4m.

Substitution and deadweight were calculated based on data from the survey to alumni. In terms of substitution, EPSRC fellows may receive preferential treatment at their host institutions as a result of having been awarded the fellowship. For example, EPSRC fellows' reduced teaching schedules can be counteracted with higher teaching schedules for their peers (i.e. research staff). This substitution effect is estimated to be 7.6%. [21] Regarding deadweight, it is likely that without the grant, EPSRC fellows would still be able to pursue (some of) their research interests, drawing from other grants and income. Deadweight is estimated to be 11.6%. [22]

Table 32 provides an overview of the return on investment estimates after adjusting for displacement, substitution effect and deadweight.

Table 30 Estimated benefits, in millions

	Wage premium	Spinout additional GVA	Patent value	Knowledge spillovers	Total benefits
A. Total, before adjustments	£8.3	£317.5	£24.8	£477.5	£828.1
B. Grossing up [3%]	£0.3	£10.5	£0.8	£15.8	£27.5
C. Displacement – 1 [49%]	£4.1	£155.6	£12.1	n/a	£171.8
D. Displacement - 2 [£1.4]	£1.4	n/a	n/a	n/a	£1.4
E. Substitution	£0.6	£24.2	£1.9	n/a	£26.7
F. Deadweight	£1	£36.7	£2.9	n/a	£40.5
Total, after adjustments [A + B – C – D – E – F]	£1.5	£111.6	£8.7	£493.4	£615.2
Years over which benefits accrue	**31**	**50**	**20**	**20**	

The total estimated benefits of the portfolio of fellowships funded, after adjusting for displacement, substitutions and deadweight, amounts to £615.2m. The estimated benefits reflect the value of the EPSRC investment with adjustments made for co-funding. The total benefits are grossed-up by 3% based on the assumption that the proportion of fellows that did not submit to Researchfish perform on par with the average grant holder. After grossing-up, the total benefits reflect the full portfolio of fellowships funded. In all estimates, the analysis attributes a proportion of the wider benefits to the EPSRC fellowship and accounts for displacement, substitution and deadweight by discounting the value that would have been

[21] The substitution effect was calculated based on the average number of teaching hours transferred to peers as a percentage of the number of hours in a typical 40 hours working week (alumni survey).

[22] The alumni survey sub-question 'time for research' was the main component for calculating deadweight. The average response is calculated on a 0-5 scale. An overage of '5' would indicate 0% deadweight and an average of '0' would suggest 100% deadweight.

obtained anyway in the counterfactual scenario in which the programme did not exist. These benefits are accrued over several years. The analysis assumes, for instance, that the wage premium is enjoyed for up to 31 years (from age 30 for post docs to retirement at age 61). The analysis also assumes that the additional GVA from spinouts is realised over a period of 50 years, which has been set as the maximum life of a firm. Patents are assumed to yield returns over a period of up to 20 years. The key assumptions and impact estimates are summarised in Table 31.

Note that the counterfactual compares the EPSRC fellowships to a situation where a researcher did not receive a fellowship (i.e. he/she was not awarded resources/time to invest in e.g. research and innovative activities). The counterfactual does not compare the effect of the fellowship to non-researchers and it also does not conclude that other programmes, that offer grants and/or fellowships, and thereby are providing researchers broadly similar opportunities, are associated with a relatively lower/higher returns.

Table 31 Impact estimates and assumptions

Type of impact	Key assumptions	Total estimated 'benefits' to the community without EPSRC fellowships	Total additional estimated benefits as a result of the EPSRC fellowships (Conservative scenario)	Total estimated 'benefits' to the community with EPSRC fellowships (Conservative scenario)
Career progression **Wage premium**	Counterfactual: • The wage premium is assumed to amount to 1.04% for all types of EPSRC fellows, it is assumed that fellows will see an increase in salary of 1.04% after their fellowship in contrast to a situation where they would not have been awarded the fellowship and that increment will persist for the rest of their careers (based on the alumni survey) Other assumptions: • The base salary corresponds to the average pay of staff in scientific research and development, per age bracket (ONS 2019)	£794.1	£1.5	£795.7
Knowledge and innovation (direct effects) **Additional value of spin outs**	Counterfactual: • A 70% higher survival rate is expected from spinouts created by fellows, as the literature shows that university spinouts have higher odds of survival than 'regular' start-ups Other estimates & assumptions: • It is estimated that fellows launched an average of 3.0 spinouts per year, in the period 2006-2016 (based on data from Researchfish) • Average Gross Value Added (GVA) and average survival rate of spinouts is based on data from ONS and Eurostat	£16	£111.6	£127.2
Knowledge and innovation (direct effects) **Additional value of**	Counterfactual: • The value of patents generated by fellows is assumed to be 5% higher, as the literature shows patents from university researchers are of higher quality than 'regular' patents, and	£294	£8.7	£302.5

Type of impact	Key assumptions	Total estimated 'benefits' to the community without EPSRC fellowships	Total additional estimated benefits as a result of the EPSRC fellowships (Conservative scenario)	Total estimated 'benefits' to the community with EPSRC fellowships (Conservative scenario)
granted patents	higher quality translates into higher economic value Other estimates & assumptions: • It is estimated that fellows were granted, on average, 3.7 patents, in the period 2007-2015 (based on data from Researchfish) • The value of patents was obtained from a survey that shows the value patent portfolio of UK inventors (Patval, 2017). The data accounts for the fact that only a small percentage of patents generate income • Estimates are adjusted by co-funding (i.e. only account for the percentage of EPSRC funding over the total funding associated to this outcome) • Net present value is calculating using a 2% discount rate			
Knowledge and innovation (spillover effects)* Value of granted patents to other stakeholders	Counterfactual: • The patents that cite the research carried out by EPSRC fellows may have been of lower value without the EPSRC research. The assumed additionality is equivalent to the proportion of non-patent literature citations in these patents (the median value of NPL citations is 27, therefore an attribution of 3.7% is assumed) Other estimates & assumptions: • Data from a survey to UK inventors (Patval, 2007) is used to estimate the value of the portfolio of patents	£7,811	£493.4	£8,304.2

Notes: The total GVA of the spinoffs is £265.1m after accounting for the 70% survival premium and before attributing impact to the EPSRC Fellowship programme. All the monetised values expressed in 2019 sterling pounds.

5.3 Estimated total costs

The total costs of the fellowship to the EPSRC are assumed equal to the (reporting) value of the fellowships which amounts to (close to) £400m see Table 32. These reporting values ignore the cost of running the fellowship programme, promoting the programme, and ignore monitoring and evaluation costs.

In addition to the reporting values presented in Table 32, EPSRC fellows' project partner contributions amount to £43.4m. These project partner contributions are a type of co-funding and best practice see this value treated as a public cost (when from public sources) or as an opportunity cost (when from a UK based business or charitable organisation) in a RoI estimation. It is however assumed that any benefits from this co-funding in terms of research outputs, outcomes and impact are also valued in the RoI estimation. The modelling does not allow disentangling the benefits from EPSRC funding and those from co-funding.

Estimated total costs amount to £442.5m.

Table 32 Operational costs by fellowship type (EPSRC funding, excluding co-funding)

Fellowship type	Number of Fellowships awarded	Grant value - average	Grant value - Min	Grant value - Max	Grant value - Total grant value
Career Acceleration Fellowship	107	£748,696	£349,723	£1,440,647	£80,110,457
EPSRC Fellowship	214	£715,849	£136,753	£1,908,377	£153,191,645
Leadership Fellowships	69	£1,215,726	£345,211	£2,016,328	£83,885,064
Postdoc Research Fellowship	158	£224,789	£102,918	£382,793	£35,516,705
Senior Fellowship	18	£674,768	£345,848	£1,163,907	£12,145,825
Standard Research	37	£923,919	£243,145	£1,122,267	£34,185,004
Total	**603**	**£661,749**	**£102,918**	**£2,016,328**	**£399,034,700**

5.4 Return on investment

Return on Investment calculations are made for different scenarios: a 'pessimistic scenario', a 'conservative scenario', and an 'optimistic scenario'. Under the do-nothing scenario there are no benefits. In the pessimistic and optimistic scenarios, the sensitivity of the initial/conservative assumptions are tested for the impact dimensions wage premium (1.04%), spinouts' additional survival rate (70%), university patent premium (5%) and knowledge spillovers attributed to the programme (3.7%). The pessimistic scenario assumes that all these parameters in the estimations are 30% lower than what is assumed in the conservative scenario, while the optimistic scenario assumes that all parameters are 30% higher (see Table 33).

In accordance with the conservative scenario, it is estimated that the total additional benefits of the programme amount to £615.2m. The costs to the programme are estimated to amount to £442.5m, which includes co-funding sourced by EPSRC fellows. The estimated **return on investment of the EPSRC Fellowship Programme is 1.39, for every £1 invested in the EPSRC Fellowship Programme there is an additional benefit of £0.39 compared to researchers not having received the fellowship. This is a positive result and most likely an underestimation of the impact of the programme as it only captures the impact that is monetised through the four channels of impact.**

The model does not capture the wider benefits of the research conducted, beyond what can be traced through the analysis of patent data. For example, there are technologies and product innovations that may be realised without inventors investing the time and resources to file a patent. Moreover, there are many possible wider social benefits, e.g. impact on health and wellbeing, that may be realised as a result of the research conducted and these benefits are not included in the modelling, or the impact from fundamental scientific discoveries that need more time to materialise into measurable benefits. Estimating the (monetised) value of these wide benefits is out of the scope of this study.

Table 33 Estimated Return on Investment - scenarios, in millions

	Scenario 0 (Do nothing)	Scenario 1 - pessimistic	Scenario 2 - conservative	Scenario 3 - optimistic
Career progression **Wage premium (31 years)**	£0	£0.7	£1.5	£2.4

	Scenario 0 (Do nothing)	Scenario 1 - pessimistic	Scenario 2 - conservative	Scenario 3 - optimistic
Knowledge and innovation (direct effects) **Additional value of spin outs (50 years)**	£0	£58.5	£111.6	£162.5
Knowledge and innovation (direct effects) **Additional value of granted patents (20 years)**	£0	£6.1	£8.7	£11.3
Knowledge and innovation (spillover effects) **Value of granted patents to other stakeholders (20 years)**	£0	£345.3	£493.4	£641.4
Total additional benefit	£0	£410.6	£615.2	£817.6
Cost	£0	£442.5	£442.5	£442.5
Investment gain	**£0**	**-£31.8**	**£172.7**	**£375.2**
Return on Investment (additional benefit per £ spent)	-	-	**1.39 (0.39)**	**1.85 (0.85)**

Table 33 presents the RoI results where project partner contributions are treated as a cost. However, despite its nature in a RoI (and/or Cost Benefit Analysis) framework, involvement of project partners in public research activities is considered a positive outcome as it is a source of knowledge transfer between academia and industry and because it too helps leverage further funding. To enable comparison, Table 34 presents the results of the RoI estimations when co-funding is considered as a benefit instead of a cost.

Table 34 Estimated Return on Investment - scenarios, in millions – co-funding considered as a benefit

	Scenario 0 (Do nothing)	Scenario 1 - pessimistic	Scenario 2 - conservative	Scenario 3 - optimistic
Total additional benefit	£0	£411	£572	£818
Cost	£0	£399	£399.0	£399
Investment gain	**£0**	**£12**	**£173**	**£419**
Return on Investment (additional benefit per £ spent)	**-**	**£1.03 (0.03)**	**£1.43 (0.43)**	**£2.05 (1.05)**

5.5 Limitations of the analysis

Estimating the economic benefit of the EPSRC fellowship programme is subject to several limitations. The estimations are the result of several assumptions made on likely impact.

It has not been the scope of the economic impact analysis to capture the full impact of the programme. The model seeks to capture the economic impact on EPSRC fellow/alumni and ignores other benefits of the funding to researchers. For example, the funding provides researchers freedom to pursue research in their interests, it provides them with recognition and prestige at the time of winning the grant as well as through the work accomplished during the fellowship.

The model does not capture impact on the research community and/or seek to assess the value to researchers' peers/colleagues in the UK and abroad. The model also does not capture the wider benefits of the research conducted, beyond what can be traced through the patent analysis. For example, there are technology and product innovations that may be realised without inventors investing the time and resources to file a patent. Moreover, there are many possible wider social benefits, e.g. impact on health and wellbeing, that may be realised as a result of the research conducted and these benefits are ignored in the modelling.

6 Comparison with other fellowships

We identified six fellowship schemes that provide fellowships for academics and non-academic practitioners to develop novel research activities; such as establishing international research collaborations, inter-sectoral mobility, and skills training. In our search we aimed to identify both programmes that were comparable to the EPSRC fellowships in scope and those could provide useful design insights. We present key points related to scope, support mechanisms and learnings below informed by the information in Table 35, which gives a mapping of the six fellowship schemes.

6.1 Scope of the programme/scheme

Aims and objectives

EPSRC's fellowship schemes have clear aims linked both to supporting the fellow's career path and to contributing to the wider global body of knowledge, and STEM, as a whole. In general, the comparator schemes do aim to support researcher careers (e.g. URFs, Future Leaders), but this is often expressed differently. For example, the Newton Advanced Fellowships provide development via international experiences and RAEng industrial fellowships do the same by intersectoral collaboration. One outlier is the Leverhulme Trust's Major Research Fellowship, which simply allows researchers to develop novel research with no other intended outcomes.

Most of the schemes identified here do not explicitly aim for their fellows to have socioeconomic impacts in the same way that EPSRC expects its fellows to. In this way, EPSRC is more outwardly aspirational of its fellows than comparators from the outset. However, there are two exceptions. The Marie Skłodowska-Curie individual fellowships goals are directly tied to R&I development in Europe by bringing talent to research organisations in EU countries. The UKRI Future Leaders fellowships are similar in that they aim to retain and bring talent to the UK.

There are two examples that aim to benefit both UK and developing country R&I. The URF does this as a sub-set of its grants by awarding a handful under the Global Challenges Research Fund (an Official Development Assistance fund). The Newton Advanced Fellowships (another ODA fund) do this more directly as development benefits are primary to UK benefits. These emphasise international collaboration and challenge led approaches, which are less of a focus for EPSRC fellowships. Though not at such a scale, Marie Skłodowska-Curie individual fellowships and RAEng industrial fellowships also aim to have an impact at sector level by increasing collaboration and mobility (both ways).

Eligibility

In general, most schemes target early to mid-career researchers. However, the criteria for how much experience they have and where they come from does differ. For EPSRC fellowships, there are no eligibility rules based on years of post-doctoral experience, which is not the case for all the comparator schemes identified here. Some require a permanent academic position (e.g. NAFs) and some stipulate a number of years' experience or a PhD (e.g. Individual Fellowships). Industrial fellowships also require industrialists to have five years of experience and be educated to degree level in engineering. These can be restrictive. EPSRC and others (e.g. UKRI Future Leaders) tend to be more open and flexible with applicant eligibility.

6.2 Key support mechanisms

EPSRC fellowships allow for the costs of most research and developmental activities to be covered. This includes travel, training and visiting researchers. All these features are important for the career development of fellows (e.g. travel and visits would imply internationalisation). These costs were not always covered in the comparator schemes we identified. For example, NAFs budgets were relatively restrictive in terms of what could be covered (e.g. PhD student travel costs not covered) and Industrial Fellowships did not cover research costs, only time. URFs, NAFs, Individual Fellowships and Future Leaders did also cover elements such as training, often providing clear budgets for these activities.

On the other hand, some other comparators did include support features that EPSRC fellowships do not explicitly provide. For example, RAEng's Industry Fellowships offers a mentoring programme as part of the programme, as does their SME Leaders scheme. This is not to say that EPSRC fellows are not mentored and do not mentor others, but that there is no structural support for this. This is also the case for collaborations. They are not discouraged in EPSRC schemes but are also not built-in like they are for the NAFs, Individual Fellowships and GCRF URFs.

Very few appear to offer support to build the fellow's team except for URFs and Future Leader fellowships. EPSRC also offer this, but not for all fellowship types. This is to be expected for early career fellows, but team building is an important aspect of mid to established career fellows.

6.3 Strengths, limitations and key learnings

Positive features included long-term fellowships, flexible eligibility criteria, all activity costs covered and international collaboration supported.

Many of the fellowships we identified include some explicit international element. The aim of establishing research independence is bolstered by internationalisation and many funds/initiatives recognise this. Also, the criteria for excellent research requires work to be world leading, which is often only possible by international collaboration. EPSRC may consider adding a stronger international collaboration element to their fellowships, whether that be to include this as an encouraged eligible activity or creating a new fellowship variant with a specific mandate to do this.

One other interesting point is that successful applicants to the UKRI Future Leaders fellowship who require a visa to work in the UK are eligible to be considered under the fast-track Global Talent Visa route. This visa route is designed for researchers / innovators and gives the holder flexibility to pursue their research and collaborations. If EPSRC were to open up their fellowships to international applicants, this would be one way to do this.

Common limitations were: little opportunity to commercialise work, highly competitive funding rounds, and small or inflexible budgets that did not cover a wide range of activities. EPSRC fellowships do not suffer from any of these except perhaps competitiveness, which EPSRC can do little about and does indicate high-demand.

In the table below we have suggested some key learnings. These are largely around including some sort of international/mobility element to the EPSRC fellowships, whether that be in terms of objectives (e.g. ODA related), exchange or secondment (e.g. NAFs and Individual Fellowships), or in terms of applicant eligibility (e.g. Future Leaders). We also recommend EPSRC assess whether adding additional inclusive options for their fellowships would be beneficial. For example, Future Leaders offers part-time and job share options, and Royal Society Dorothy Hodgkin Fellowships offer a chance for those who require a flexible working pattern due to personal circumstances, such as parenting or caring responsibilities or health issues.

Table 35 Comparison of fellowships

Fellowship and funder *(similar EPSRC fellowships)*	**Scope**	**Key support mechanisms**	**Strengths and limitations**	**Key learnings**
University Research Fellowship - Royal Society *(similar to post-doc and early career fellowships)*	Aims: To establish an independent research group and therefore independent researcher status. Expected to be strong candidates for permanent posts in universities at the end of the fellowships Eligibility: For outstanding postdoctoral researchers with the potential to become leaders in their chosen field. Must be within the Royal Society's remit of natural sciences, 3-8 years of post-PhD research experience 1400 awards since 1983, up to 8 years of funding for salary, expenses and assistance. Up to three awards via GCRF providing activities are ODA eligible in an OECD DAC list country	• Salary - 80% of the basic salary costs up to £40,681.46 in the first year, estates costs and indirect costs • Expenses – £13,000 in year one and £11,000 thereafter. This includes enhanced expenses in 2020 only • Assistance - 80% of the full economic cost of a postdoctoral researcher • Other: PhD student, equipment, public engagement, training	Long-term contributions to salary, expenses and research assistance (i.e. post-doc). Some support international development. Funding for training and professional development for the Fellow and any staff or students on the grant Little opportunity to commercialise their work. Historically few achieve very senior positions (i.e. chairs). Very competitive.	EPSRC's post-doc fellowships are very similar in terms of aims (independence) and benefits (training of themselves and others). A key advantage of these fellowships is their length. EPSRC fellowships are no more than five years. It may be worth exploring the advantage of longer-term grants, which might include a high level of stability for the research
Newton Advanced Fellowships - Royal Society and AMS *(similar to established career fellowships)*	Aims: Collaborative science awards funding UK and DAC list country researchers. Focuses on skills development in developing countries as well as producing research products. Establishing long term links between organisations Eligibility: 199 awards as of 2019, £111k over 3 years for early to mid-career researchers with less than 15 years research experience and a permanent academic position. Must be within the Royal Society's remit of natural sciences	• Salary top up (£5,000) for researcher in the partner country • Research support (£15,000 p/a) • Travel & subsistence (£12,000 p/a) • Training (£5,000 p/a)	Strong emphasis on DAC list country researcher training and development Budget is relatively limited per award and cannot be flexibly spent across years. Does not cover salary (except the top up)	These fellowships aim to add an element of internationalisation and development experience to the careers of established UK researchers. This is one way of developing careers. This benefits both the UK and developing countries
Individual fellowships - Marie Skłodowska-Curie Actions *(similar to post-doc fellowships)*	Aims: Skills acquisition through advanced training, international and intersectoral mobility as well as producing research products. High-level EU objectives e.g. *"Better quality research and innovation contributing to Europe's competitiveness and growth"* Eligibility: 9,000 awards as of 2017, €200k per fellow over 18 months for experienced researchers (PhD or 4 years experience)	• Living, travel and family costs • May opt to include a secondment phase in Europe, notably in the non-academic sector • Contributes to training, networking and research costs, as well as management and indirect project costs	Multiple options for fellows to engage in training and secondments across Europe and sectors. Covers all subjects. Some issues with the level of financial support across the different types of fellows	A good example of using mobility to further economic development. The secondments are interesting tools for this that could be applied within the UK as opposed to outside of it
Industrial Fellowships – RAEng *(similar to manufacturing fellowships)*	Aims: Collaborative cross sector research fellowships where one party would host the other. aims to strengthen the strategic relationship between industry and academia by providing an opportunity to establish or enhance collaborative research between the two parties. Eligibility: £50k p/a over 6-24 months for mid-career academics and industrialists. Academic applicant must hold a permanent position. Two years teaching	• Contribution towards salary costs • Fellows receive mentoring (only if award is over one year long)	Cross sectoral type fellowships are less common. Allows both academia to industry and vice-versa. Collaborative Does not cover research costs (e.g. consumables). Restrictive eligibility	Another example similar to manufacturing fellowships that aims to benefit the UK economy in the long run. Provides a relatively low-cost fellowship scheme to boost cross sector working. Could be a pre-cursor to manufacturing fellowships, or an option for

Fellowship and funder *(similar EPSRC fellowships)*	**Scope**	**Key support mechanisms**	**Strengths and limitations**	**Key learnings**
	experience. Industry applicant must have 5 years' experience in engineering, hold a permanent position and be degree qualified			established/post-doc fellows for one year within their grant
Major research fellowships – Leverhulme Trust *(some similarities to post-doc fellowships)*	Aims: Funding to complete a discrete piece of research for researchers in the humanities and social sciences. Particularly aimed at those who are or have been prevented by routine duties from completing a programme of original research Eligibility: Salary and costs over 2-3 years for established researchers. Must be employed by a university. Should be able to demonstrate scholarship at the highest level (with proof that it has garnered international recognition)	• Covers salary costs • May also request research expenses up to an annual maximum of £6,000 • Equipment under £1,000	For researchers somehow prevented from conducting their research Relatively low value awards compared to other programmes, no training. Wider applications (e.g. commercialisation) are not applicable	Focuses particularly on those prevented from doing their research. Not a unique feature in the landscape (e.g. Royal Society DHFs) but a useful feature. EPSRC does offer this to some extent in terms of returning to academia, but could be extended
Future leaders – UKRI *(Similar to Challenging engineering)*	Aims: Flexible, long-term awards in R&I supporting researchers to become independent. Aim is to develop, retain, attract and sustain research and innovation talent in the UK. Also aims to enable the fellow to transition to or establish their research/innovation independence Eligibility: £1.5m over 4-7 years, open to early career researchers and innovators from around the world in all sectors (hosted in the UK). 208 awards after 3 rounds. No rules around years since PhD or permanent job roles	• Salary, research and expenses • Costs for all equipment, materials, travel, overheads and any other programme related costs • In addition to the fellow's salary, those salaries of any research/innovation staff working on the fellowship can be included • Costs can be claimed to undertake training and development activities	Very flexible awards for all types of researchers in R&I, longer-term and higher value than most fellowships Extremely competitive with low success rates (so far)	The approach is relatively risky in that it is more open than most fellowships, high-value and long-term. However, their flexibility (e.g. part-time / job share) could be added to some EPSRC fellowships. Flexibility in eligibility could also be helpful for inclusion. Could also be used to attract international talent

7 Conclusions and recommendations

7.1 Conclusion

The EPSRC fellowship programme is a prestigious award that enables the delivery of excellent research and further contributes to the research and innovation landscape, delivering high economic impact.

There is an almost universal agreement among fellows that the main immediate benefit of taking part in an EPSRC fellowship is the opportunity to focus on their research due to the lack (or reduction) of other obligations, including teaching and administrative duties, in comparison with their peers. The fellowship also provides them the freedom and independence to explore their own ideas, and change direction to follow new research paths. Time and money also allow them to explore 'riskier' research paths and engage in collaborations with academics in the same field, multidisciplinary teams and industry. There are also positive reputational effects of receiving what is considered a prestigious award. Almost all fellows would recommend their EPSRC fellowship to others, and even with the benefit of hindsight, they state that they would still prefer a fellowship over a grant.

In terms of direct benefits to fellow, the evidence shows benefits in terms of scientific production, career progression and opportunities to collaborate. In total, EPSRC Fellowships have led to the publication of 11,775 research papers, which have an Average Relative Citation (ARC) of 2.06,[23] which means that these are cited two times more frequently compared to the world level (i.e. 1.0). This is in line with similar impact measures for the EPSRC as a whole (e.g. 2.06 in Field-Weighted Citation Impact[24]). However, 25% of the top 10% Highly Cited Publications (HCP 10%), in their respective fields, come from EPSRC fellows.

About a half of the 603 fellowships reported collaborations with partners in the UK (46% of collaborations) and across the globe including Europe (27% of collaborations), according to ResearchFish. This leads to a virtual circle that enables, among other things, further access to funding, with an estimated £43.4m leveraged from collaborators and £809.1m further investment captured by EPSRC fellowship alumni according to ResearchFish.

With regard to career development, 93% agreed that the fellowship had made a significant difference to their career path. 86% of respondents agreed that it had impacted on the level of seniority they had reached, with similar proportions agreeing they had experienced faster career progression than they would have done without a fellowship.

As expected, different schemes have different effects. Targeted fellowships are more likely to lead to increased research impact and improved collaboration abilities, while unsurprisingly fellowships to established researchers are less likely to influence career progression and research independence (as reported by survey respondents). Fellows have an accelerated career trajectory (as confirmed in the survey and interviews), with early career researchers in particular agreeing that it was easier to secure a permanent position after their fellowship.

[23] 8,104 papers have a valid RC (Relative Citation): publication sets from which citation-based bibliometric indicators are computed. Only papers published in 2017 or earlier have an RC score.

[24] https://epsrc.ukri.org/newsevents/pubs/publicationsanalysis/

In terms of wider impact, the scientific knowledge produced, by fellows, and its dissemination as well as the training of the future generation of researchers enables wider social and economic impact.

Fellows have contributed to the training of the next generation of researchers, supervising doctoral researchers, managing other researchers and leading a research group, and reviewing and managing staff performance during their fellowship.

Additionally, there are a series of innovation outcomes emerging from the fellowships, including the creation of spin outs (and the new jobs associated with them) and new inventions (and its proxy, patents) associated to fellows, as well as and further knowledge flows that also materialised in new inventions in the wider society.

There is also evidence of wider uptake by academics, industry and policymakers. The majority (59%) of survey respondents suggest that their research has been used, at least to some extent, by industry and business and 22% suggest it has been used, at least to some extent, by policymakers. Advocacy activities are also resulting in longer term impact in the research, economic and regulatory domains.

Furthermore, research from EPSRC fellowships is contributing towards health, social and environmental impacts. For instance, research has contributed to the development of new imaging methods that have been taken up by MRI scanner vendors and to the development of imaging techniques for neurology and cancer diagnosis and monitoring. Research has also helped secure the supply of safe drinking water from ageing infrastructure and contributed to new industrial collaborations on solar energy. One Early Career Fellowship recipient "*worked with Electricity North West to deliver a decision making tool which to date has saved £5 million for customers*". This work has been picked up by the National Grid as best practice. One former postdoctoral fellow indicated that his work on uncertainty quantification for climate modelling is used regularly for policy analysis at the European Commission and is expected to be used by the UK government.

Our economic assessment of benefits shows that the estimated benefits of the portfolio of fellowships funded, after adjusting for displacement, substitutions and deadweight, amount to £615.2m under conservative assumptions. We also estimate that return on investment (ROI) of the EPSRC Fellowship Programme is 1.39. For every £1 invested in EPSRC Fellowships there is an additional benefit of £0.39. This is a positive result and most likely an underestimation of the impact of the fellowships as it only captures the impact that is monetised through the four channels of impact indicated above.

Finally, our analysis of other scheme show that the EPSRC fellowships offer more support and are designed to increase the likelihood of impact in comparison with other schemes.

7.2 Recommendations

Based in the evidence collected in this report, we have drafted a series of recommendations that could be taken into consideration for future iterations of the fellowships. They are preliminary and require further validation with ESPRC.

Providing extra clarity to Host Agreements and managing expectations. Most fellows were satisfied with the support provided by the host organisations, however, where dissatisfaction existed this was mostly linked to the host. There seems to be scope for providing more specific written commitment of their support, including how much teaching and administrative responsibilities relief will be given and for EPSRC to follow-up on how this worked in practice.

It appears also that more clarity could be provided regarding the host institution's obligations at end of the fellowship, for example, whether that is the guarantee of a permanent position or the opportunity to apply for one. Hosts may also be invited to discuss with fellows the potential career paths, right at the outset.

Better balance of awards in terms of experience - Although there are benefits from the openness of fellowship schemes in terms of the research experience of applicants, several respondents noted that this may have an unintended consequence of being less accessible to early career researchers, particularly recent doctoral graduates. Applicants with less experience may struggle to compete with applicants at the higher end of the eligibility range with more experience and stronger track records. If fellowship schemes continue to be open to a wide range of researchers in terms of experience, specific attention should be paid in peer-review panels to ensure a balance of awards across the eligibility range and that reviewers are not (unconsciously) favouring applicants with more research experience.

There was also a suggestion, from some fellows, to allow for broader thematic focus. However, it is our view that supporting specific strategic areas goes in line with the current UKRI's and government's ambitions around the industrial Strategy.

Appendix A Overview of Fellowships funded

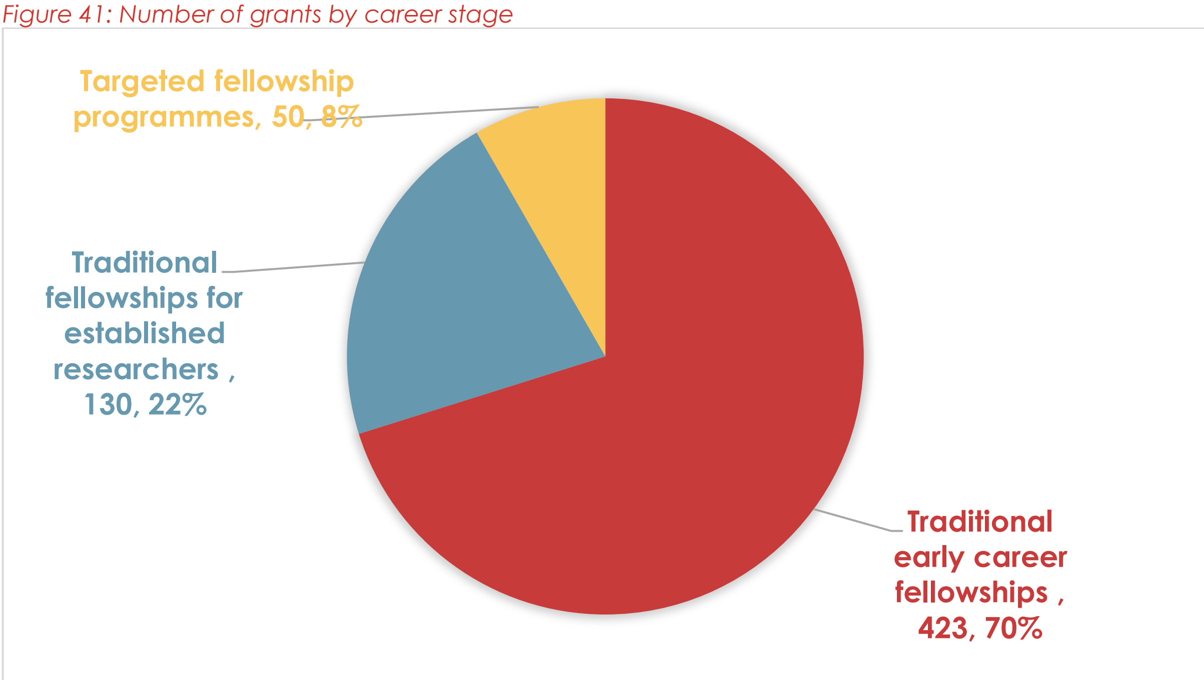
A.1. Fellowship type

The different type of EPSRC fellowships funded are summarised in Figure 41 and Figure 42 below.

The vast majority (423) of fellowships are awarded to researchers and fellows who are considered to be an early stage of their career; by contrast, funding provided to established careers and targeted fellowship programmes account for merely one third of all fellowships and research grants – see Figure 41.

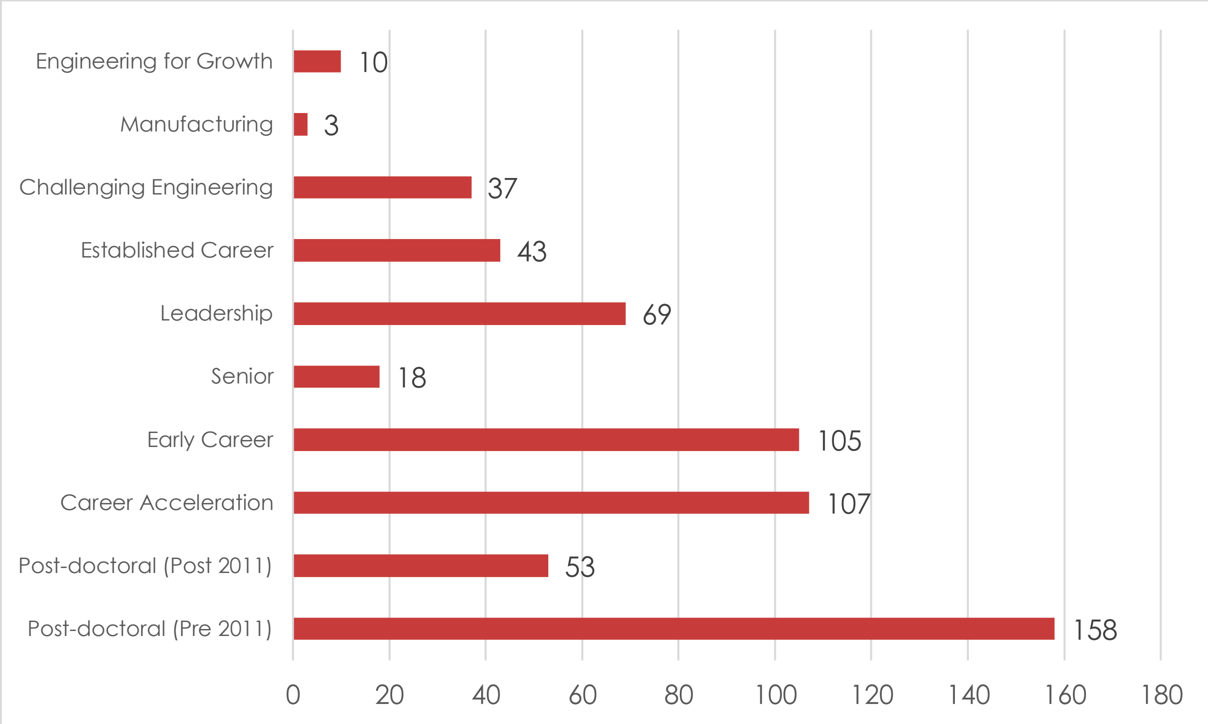
Fellowships provided to 'Traditional early career fellowships' are defined to include 'Post-doctoral fellowships' (211), 'Career Acceleration fellowships' (107) and 'Early Career fellowships' (105) with 'Post-doctoral fellowships awarded before 2011' as the biggest single group (158). The remaining fellowships are awarded through the following schemes: 'Leadership' (69), 'Established Career' (53) 'Senior' (18) 'Engineering for Growth (10) and Manufacturing (3), 'Challenging Engineering' – see Figure 42.

Figure 41: Number of grants by career stage



N = 603

Figure 42: Number of grants by type



N = 603

A.2. Award year

Table 36 shows the number of grants per Fellowship scheme and by year of award. Fellowships that are completed at the time of reported were awarded between 2005 and 2018.

Table 36: Awarded funding by type of grant and year

	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Grand Total**
Post Doc - Pre 2011	10	15	19	28	28	32	24	2							**158**
Post Doc - Post 2011								1	10	12	11	11	6	2	**53**
Career Acceleration				16	26	29	31	5							**107**
Early Career								7	46	33	13	5		1	**105**
Senior Fellowships	2	7	6	3											**18**
Leadership				15	16	21	13	4							**69**
Established Career								8	22	8	3	1	1		**43**
Challenging Engineering	1	9	6	3	5	3	10								**37**
Manufacturing										2		1			**3**

Engineering for Growth										10					**10**
Grand Total	**13**	**31**	**31**	**65**	**75**	**85**	**78**	**27**	**78**	**65**	**27**	**18**	**7**	**3**	**603**

A.3. Grant value

Table 37 presents a breakdown of the grant value (reporting value) of the awarded fellowships by fellowship type. The biggest total amount has been devoted to the ‘Leadership’ scheme, which funded 69 fellowships. The ‘Leadership’ scheme provided, on average, the highest grant to individual fellows, similar to the levels of funding awarded through the ‘Established Career’ scheme. The ‘Challenging Engineering’, ‘Manufacturing’ and ‘Engineering for Growth’ schemes provided similar grants sizes, i.e. around £1m. The Post-doc Fellowships are associated with relatively lower grant funding (between £225k and £262k on average).

Table 37 Grant value, by fellowship type

Fellowship type	Number	Min	Max	Average	Total
Post Doc - Pre 2011	158	£102,918	£382,793	£224,789	£35,516,705
Post Doc - Post 2011	53	£199,382	£375,603	£262,040	£13,888,120
Career Acceleration	107	£349,723	£1,440,647	£748,702	£80,111,154
Early Career	105	£136,753	£1,815,952	£728,813	£76,525,353
Senior Fellowships	18	£345,848	£1,163,907	£674,768	£12,145,825
Leadership	69	£345,211	£2,016,328	£1,215,726	£83,885,064
Established Career	43	£599,282	£1,908,377	£1,151,841	£49,529,158
Challenging Engineering	37	£243,145	£1,122,267	£923,919	£34,185,004
Manufacturing	3	£1,071,470	£1,270,945	£1,184,498	£3,553,495
Engineering for Growth	10	£803,872	£1,236,949	£969,552	£9,695,519
Grand Total	**603**	**£102,918**	**£2,016,328**	**£661,750**	**£399,035,397**

A.4. Research Organisation

Table 38 Overview of fellowships awarded by university (47 in total – at the time of application)

Universities	Number of fellowships
University of Oxford	84
Imperial College London	75
University of Cambridge	65
University of Bristol	36
University College London	33
The University of Manchester	27
University of Warwick	27
University of Edinburgh	23

University of Nottingham	23
University of Bath	16
University of Southampton	16
University of Leeds	15
University of Glasgow	14
University of Sheffield	12
University of St Andrews	12
University of Birmingham	11
Durham University	9
Queen's University of Belfast	9
University of Exeter	9
University of Strathclyde	9
King's College London	8
Queen Mary University of London	7
Cardiff University	6
Newcastle University	6
Lancaster University	5
University of Surrey	5
Loughborough University	4
University of Liverpool	4
University of York	4
University of Reading	3
University of Sussex	3
Cranfield University	2
Heriot-Watt University	2
Royal Holloway, Univ of London	2
University of Dundee	2
University of Hertfordshire	2
University of Kent	2
University of Leicester	2
Aston University	1
City, University of London	1
London School of Economics & Pol Sci	1
MRC Centre Cambridge	1
Open University	1
Swansea University	1
University of East Anglia	1
University of Huddersfield	1
University of the West of England	1
Grand Total	**603**

A.5. Subject area / discipline

Data on 'subjects' are taken from the 'Gateway to Research' database that hold information for 553 or 92% of the 603 investigated fellowships and research grants.

At least 24% of all fellows report to have conducted research in the area of mathematical sciences and 16% of fellows report to have conducted research in the area of information, communication and Technology – see Table 39.

Table 39: Number of fellowships by subject

Subject	Number of fellows	Percentage of subject entries	Percentage of fellows (603)
Mathematical sciences	142	18%	24%
Info. & commun. Technol.	97	12%	16%
Materials sciences	61	8%	10%
Optics, photonics & lasers	58	7%	10%
Medical & health interface	45	6%	7%
Tools, technologies & methods	44	5%	7%
Chemical synthesis	40	5%	7%
Supercond, magn. &quant.fluids	40	5%	7%
Catalysis & surfaces	35	4%	6%
Energy	32	4%	5%
Biomolecules & biochemistry	25	3%	4%
Atomic & molecular physics	21	3%	3%
Particle physics - theory	21	3%	3%
Materials Processing	17	2%	3%
Mechanical Engineering	17	2%	3%
Chemical measurement	15	2%	2%
Civil eng. & built environment	13	2%	2%
Chem. React. Dyn. & mechanisms	10	1%	2%
Systems engineering	10	1%	2%
Process engineering	9	1%	1%
Plasma physics	6	1%	1%
Bioengineering	5	1%	1%
Cell biology	5	1%	1%
Complexity Science	5	1%	1%
Environmental Engineering	5	1%	1%
Management & Business Studies	5	1%	1%
Manufacturing	4	0%	1%
Ecol, biodivers. & systematics	3	0%	0%
Design	2	0%	0%
Electrical Engineering	2	0%	0%

Instrument. sensor & detectors	2	0%	0%
Linguistics	2	0%	0%
Psychology	2	0%	0%
Agri-environmental science	1	0%	0%
Animal Science	1	0%	0%
Omic sciences & technologies	1	0%	0%
Pollution, waste & resources	1	0%	0%
Sociology	1	0%	0%
Grand Total	**805**	**100%**	-

Appendix B Methodology

B.1. Approach to merging and cleaning Researchfish data

B.1.1. Merging datasets

EPSRC monitoring data on 603 completed fellowships was matched with UK Research and Innovation Gateway to Research (GtR) data and with Researchfish data as provided to the study team by the EPSRC. The matching is done based the ID reference of each fellowship.

The monitoring data includes the type of fellowship, the name of the holding organisation, the duration and the value of the fellowship (reporting value). Researchfish data includes data on publications, spin-offs, Intellectual property, etc. A matching with GtR data was performed to source data on the subject field of the fellowship and the region of the grant holder.

Recipients of EPSRC funding are required to report emerging outputs and outcomes such as publications, spin outs and impact on policies, for the duration of their awards and for up to five years beyond. The fellows/alumni can report on the outcomes at any time and once a year there is a formal submission period when researchers are required to confirm that their outcomes information is accurate and up-to-date. Despite the requirement to reporting, some fellows will not have reported on their outcome. GtR data is missing for EPSRC 20 fellowships and there are 66 EPSRC fellowships without any reported records in Researchfish. The number of entries to Researchfish varies across the different types of outcome and impact – see Table 40.

From the 603 fellowships, 107 fellows transferred to another Research Organisation (RO) during the life of the award. Two fellows transferred twice and one fellow transferred three times – see Table 41. In acknowledgement of this transfer, the fellowship ID reference of the fellowship is suffixed. Outcomes reported under the original fellowship ID reference and the suffixed fellowship ID reference are considered in the analysis. When reporting by Research Organisation and region, the analysis builds on data associated with the original ID reference.

Table 40 Overview of Researchfish entries matched, by key topic

Topic	Matched entries	Number of fellowships with matched entries	Number of fellowships without matched entries
Publications	13,592	529	74
Dissemination	2,567	247	356
Awards and recognition	1,761	269	334
Further funding	1,285	301	302
Collaborations	1,239	268	335
Next destination	924	284	319
Secondment	834	532	71
Key findings	641	532	71
IP and licencing	189	66	537
Influence on policy	118	61	542
Spin outs	41	32	571

Table 41 Overview of transfers of fellowship

Transfers	Number of transfers of the fellowship
1 Transfer	104
2 Transfer	2
3 Transfer	1

B.1.2. Excluding duplications, umatched data and inconsistencies

Part of the cleaning process involved identifying possible 'faulty' data entries which are excluded from the analysis. This includes the exclusion of identical records (duplicates) and Researchfish data that does not link to the EPSRC Fellowship Programme.

There are also instances where the data entries are logically inconsistent. For example, entries where the reported date of publication pre-dates the official start date of the fellowship are excluded as no logical justification for the observed inconsistency can be provided. A complete overview of this consistency check is presented in Table 42.

Table 42 Consistency check using award date reference

Topic	Indicator	Type of 'outcome date'	Inconsistency identified as an anomaly	Number of matched entries	Number of entries excluded / Comment
Awards and recognition	Received regognition	Date of received recognition	YES	1761	6 / see UniqueIDs below 545e3626e2ec55.83890307 54633f395041c8.77423351 545de76f36d3b5.33966972 545d5ec67900d8.42740888 54626e3c33dc04.79876307 58c9928e9b34b5.14261758
Collaborations	Collaboration Monetary Contribution	Date collaboration reportedtly started Amount of contribution	YES	1239	127 (126 records where the reported start of the collaboration dates before the official fellowship begin, 1 record with implausibly high reported contribution value)
Dissemination	Dissimination	Year dissemination took place	YES	2567	11 – see UniqueIDs below r_67567864910b938d04 546b51fd8121b1.22058613 5463d3afe48b59.24766358 546df80539b935.57127283 546decf40adff6.55255462 546df4066cf346.63118827 56c5e5d82cdf04.73403206 5419b0867a66b0.14337103 5419b2aef31d54.37707685 5c8399dfbe3741.23099791 56dd98aa496002.20976603
Further funding	Funding	Date of funding start	YES	1285	7 – see OrgID below F00004672 X00000196

					F00003150 X00000348 F00004390 F00023395
Influence on policy	Exerted influence	First year of influence	YES	118	0
IP and licencing	IP protection	Year protection granted	YES	301	1 [patent granted with ID = WO/2008/029107]
Key findings	N.A.	N.A.	No	641	0
Narrative			YES	639	10 – see UniqueIDs below 545e2af79d1c92.47544667 5631e3f21ef704.75292764 56dddfc4824be8.64244099 54466bf013d510.57042322 546242e9d9a8a4.56503673 544e497f9a0fb0.96985019 5460e51f77fda1.48994104 545e9983705d52.24071279 546337d2ef6c08.22552417 56ddc9ce833f88.17155267
Next destination	New position / new role	Start date of new role	YES	924	2 - see UniqueIDs below 56d498fd3837c9.94409336, 54648e6f6f2828.05910341]
Publications	Publication	Publication date	YES	13592	165
Research Materials Tools Methods	Provided research material	First year material was provided	YES	98	0
Secondment	Secondment	Start year of secondment	YES	834	2 - see UniqueIDs below 545f790da86252.61735554-1 56d443c4e8b947.66236542-1]
Software and technical products	Technological Prodecut	First year product was provided	YES	236	2 – see UniqueIDs 546df1db77d503.13795882 5464b48d9418b5.82497515
Spin outs	Company	Year established	NO	41	It is assumed that the fellowship could have helped the spin out grow even when it was legally established prior to the award of the grant

B.2. Overview of Researchfish data and use in reporting

Table 43 Overview of Researchfish data and use in reporting

Researchfish outcome data	Main report	Case study reference
Artistic and creative products	*Not used*	
Awards and recognition	Chapter 3	Expanding UK capability and building excellence in different sectors

Collaborations	Chapter 3&5	Increased collaboration
Dissemination	Chapter 6	Advocacy
Use of facilities and resources	*Not used*	
Further funding	Chapter 5	Longitudinal investment
Influence on policy	Chapter 6	Advocacy
IP and licencing	Chapter 5&7	
Key findings	Chapter 4	Disruptive thinking
Medical products and clinical trials	*Not used*	
Narrative	Chapter 6	
Next destination	Chapter 3	Accelerated career trajectory & Developing Research Independence (post-doc)
Other outputs and knowledge	*Not used*	
Publications	Chapter 3	Accelerated career trajectory & Developing Research Independence (post-doc)
Research Materials Tools Methods	Chapter 6	Expanding UK capability and building excellence in different sectors
Research databases & models	*Not used*	
Secondment	Chapter 3	Training and Development of themselves
Software and technical products	Chapter 6	
Spin outs	Chapter 5&7	

B.3. Documents retrieved in Scopus

Table 44 Number of documents retrieved in Scopus, by document type

Document type (in Researchfish)	**Total**	**Matched to Scopus**		**Matched to Scopus bibliometric version***	
Journal Article	10,328	9,973	(97%)	9,788	(95%)
Conference Proceeding Abstract	1,965	1,248	(64%)	1,239	(63%)
Book Chapter	483	369	(76%)	270	(56%)
Sub-total	**12,776**	**11,590**		**11,297**	
Other	175	82	(47%)	79	(45%)
Book	90	22	(24%)	1	(1%)
Working Paper	72	13	(18%)	13	(18%)
Thesis	58	1	(2%)	1	(2%)
Technical Report	37	7	(19%)	7	(19%)
(blank)	33	22	(67%)	22	(67%)
Policy briefing report	15				(0%)

Preprint	5	3	(60%)	3	(60%)
Book edited	4				(0%)
Consultancy Report	3				(0%)
Monograph	2				(0%)
Technical Standard	1				(0%)
Total	**13,271**	**11,740**	**(88%)**	**11,423**	**(86%)**

Note: Science-Metrix maintains a subset of Scopus for the production of bibliometric data. This only covers articles, reviews and conference papers, and filters out some irrelevant documents for bibliometrics.

B.4. Survey to EPSRC fellows

The EPSRC provided contact details for 603 fellowship holders across 10 fellowship schemes. Of these, 549 had valid emails. Current emails for a further 28 fellows were found, giving a total sample of 574 fellows. The survey ran for 2.5 weeks from 29 April to 18 May 2020. This was during the period that the UK was in lockdown due to the Covid-19 pandemic, which, judging by the level of automatic email responses stating reduced availability due to caring responsibilities impacted on the response rate to the survey to some extent. There were 223 valid responses to the survey equivalent to a 39% response rate. The profile of respondents by fellowship type is given in Table 45.

Table 45 Profile of respondents by fellowship type

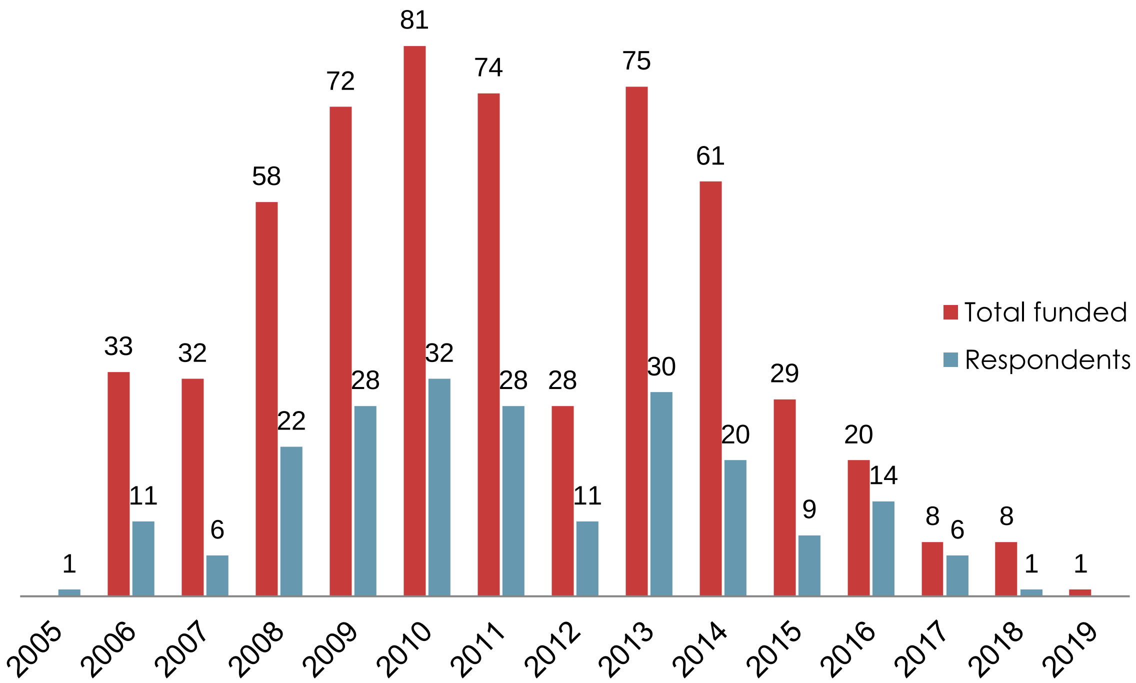
Fellowship N=223	Total	Responses	% Response rate
Early career fellowships			
Postdoctoral - Pre 2011	158	38	24%
Postdoctoral - Post 2011	53	25	47%
Career Acceleration	107	46	43%
Early Career	105	39	37%
Total	**423**	**148**	**35%**
Established career fellowships			
Senior Fellowships	18	5	28%
Leadership	69	34	49%
Established Career	43	16	37%
Total	**130**	**55**	**42%**
Targeted fellowships			
Challenging Engineering	37	12	32%
Manufacturing	3	5*	

Engineering for Growth	10	3	
Total	**50**	**20**	**40%**
Total	**603**	**223**	**39%**

*Note that there is a discrepancy between the number of responses and the number of Manufacturing fellowships granted

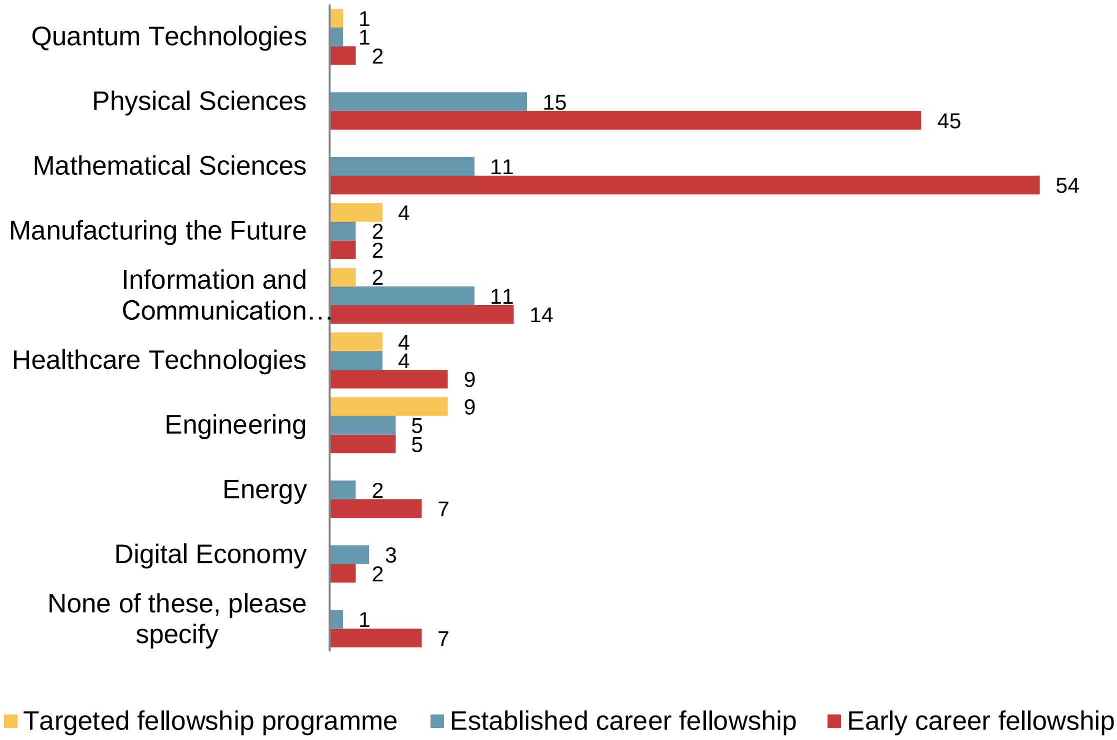
The start years for respondents' fellowships were fairly well distributed in comparison with the total number of beneficiaries in each year.

Figure 43 Number of respondents by fellowship start date (N=219)



Survey respondents covered all of the EPSRC disciplinary themes, with the majority of within mathematical and physical sciences.

Figure 44 Distribution of EPSRC disciplinary themes by fellowship type (N=222)



The fellowship have been grouped into three categories: early career, established career and targeted fellowships (see Table 46).

Overall 24% of respondents identified as women, 73% men, with 4% preferring not to say. This was fairly equally split across the three fellowship types, with slightly more male respondents in the established career fellowships.

Table 46 Gender by fellowship groups

Fellowship type **N=222**	**Man**	**Woman**	**Prefer not to say**
Early career fellowships	74%	23%	3%
Established career fellowships	79%	22%	7%
Targeted fellowships	70%	30%	-
Total	73%	23%	4%

55% of respondents were between 30-19 years old at the start of their fellowship, with 20% under 30 years old and a similar percentage 40-49 years old. 12 respondents were over 50 years old at the start of their fellowship, 3 of these over 60 years old. There were expected differences between the three fellowships types, with only early career fellowship holders being under 30 years old at the start of their fellowship. Established career fellowships had the widest age range, while the majority targeted fellowship holders were between 30-40 years old at the start of their fellowship.

Table 47 Age of respondents at the start of their fellowship

Fellowship type **N=221**	**Under 30 years old**	**30-39 years old**	**40-49 years old**	**50-59 years old**	**Over 60 years old**
Early career fellowships	30%	64%	5%	-	-
Established career fellowships	-	28%	56%	11%	6%
Targeted fellowships	-	65%	25%	10%	-
Total	20%	55%	20%	4%	1%

Respondents were also asked to give their research experience at the start of their fellowship. This included any time as a researcher in industry and excluded any periods of doctoral study or career breaks. Early career fellowship holders had the widest range of research experience with 16% having over 10 years' research experience. The vast majority of established career fellowship holders had over 10 years' research experience, while targeted fellowships had a more varied profile.

Table 48 Respondents' research experience at the start of their fellowship

Fellowship type **N=216**	**1-5 years**	**6-10 years**	**11-15 years**	**More than 15 years**
Early career fellowships	59%	25%	15%	1%
Established career fellowships	-	6%	49%	46%
Targeted fellowships	-	50%	20%	30%
Total	38%	23%	24%	15%

Appendix C Top ten most cited publications

Table 49 Top ten most cited publications, Chemistry

Citations	RC	Title	Journal	DOI
873	38.3	Ionic transport in hybrid lead iodide perovskite solar cells	Nature Communications	10.1038/ncomms8497
417	38.1	A Dysprosium Metallocene Single-Molecule Magnet Functioning at the Axial Limit	Angewandte Chemie - International Edition	10.1002/anie.201705426
405	29.7	Technologies for printing sensors and electronics over large flexible substrates: A review	IEEE Sensors Journal	10.1109/JSEN.2014.2375203
189	22.9	Report on the sixth blind test of organic crystal structure prediction methods	Acta Crystallographica Section B: Structural Science, Crystal Engineering and Materials	10.1107/S2052520616007447
234	20.7	Correlated defect nanoregions in a metal-organic framework	Nature Communications	10.1038/ncomms5176
256	18.7	Towards crystal structure prediction of complex organic compounds - A report on the fifth blind test	Acta Crystallographica Section B: Structural Science	10.1107/S0108768111042868
1966	17.6	Synthetic molecular motors and mechanical machines	Angewandte Chemie - International Edition	10.1002/anie.200504313
353	17.4	Tunable organic photocatalysts for visible-light-driven hydrogen evolution	Journal of the American Chemical Society	10.1021/ja511552k
340	14.9	The dynamics of methylammonium ions in hybrid organic-inorganic perovskite solar cells	Nature Communications	10.1038/ncomms8124
217	14.3	Conductivity studies of dense yttrium-doped BaZrO3 sintered at 1325 °C	Journal of Solid State Chemistry	10.1016/j.jssc.2007.09.027

Note that the top 10 most cited publications are selected based on the ARC (not the raw citation counts).

Table 50 Top ten most cited publications, Clinical medicine

Citations	RC	Title	Journal	DOI
825	36.1	NODDI: Practical in vivo neurite orientation dispersion and density imaging of the human brain	NeuroImage	10.1016/j.neuroimage.2012.03.072
351	24.1	Decreased gut microbiota diversity, delayed Bacteroidetes colonisation and reduced Th1 responses in infants delivered by Caesarean section	Gut	10.1136/gutjnl-2012-303249
248	17.8	Shaping cities for health: Complexity and the planning	The Lancet	10.1016/S0140-6736(12)60435-8

		of urban environments in the 21st century		
173	17.2	Spike sorting for large, dense electrode arrays	Nature Neuroscience	10.1038/nn.4268
258	15.8	The MVGC multivariate Granger causality toolbox: A new approach to Granger-causal inference	Journal of Neuroscience Methods	10.1016/j.jneumeth.2013.10.018
457	15.8	A MATLAB toolbox for Granger causal connectivity analysis	Journal of Neuroscience Methods	10.1016/j.jneumeth.2009.11.020
186	13.9	Granger causality analysis in neuroscience and neuroimaging	Journal of Neuroscience	10.1523/JNEUROSCI.4399-14.2015
374	12.9	Orientationally invariant indices of axon diameter and density from diffusion MRI	NeuroImage	10.1016/j.neuroimage.2010.05.043
149	12.7	A culture-independent sequence-based metagenomics approach to the investigation of an outbreak of shiga-toxigenic Escherichia coli O104:H4	JAMA - Journal of the American Medical Association	10.1001/jama.2013.3231
150	11.2	Diverse coupling of neurons to populations in sensory cortex	Nature	10.1038/nature14273

Note that the top 10 most cited publications are selected based on the ARC (not the raw citation counts).

Table 51 Top ten most cited publications, Enabling & Strategic Technologies

Citations	RC	Title	Journal	DOI
6061	146.9	UCHIME improves sensitivity and speed of chimera detection	Bioinformatics	10.1093/bioinformatics/btr381
537	45.6	Reversible hydration of CH3NH3PbI3 in films, single crystals, and solar cells	Chemistry of Materials	10.1021/acs.chemmater.5b00660
348	45.3	What is LiFi?	Journal of Lightwave Technology	10.1109/JLT.2015.2510021
521	36.6	Lasing spaser	Nature Photonics	10.1038/nphoton.2008.82
266	29.1	Integrated all-photonic non-volatile multi-level memory	Nature Photonics	10.1038/nphoton.2015.182
316	24.0	Shape evolution of monolayer MoS2 crystals grown by chemical vapor deposition	Chemistry of Materials	10.1021/cm5025662
268	23.8	On-chip quantum interference between silicon photon-pair sources	Nature Photonics	10.1038/nphoton.2013.339
203	22.2	Deep in vivo photoacoustic imaging of mammalian tissues using a tyrosinase-based genetic reporter	Nature Photonics	10.1038/nphoton.2015.22
906	22.0	Removing Noise From Pyrosequenced Amplicons	BMC Bioinformatics	10.1186/1471-2105-12-38

1407	21.8	Review: Current international research into cellulose nanofibres and nanocomposites	Journal of Materials Science	10.1007/s10853-009-3874-0

Note that the top 10 most cited publications are selected based on the ARC (not the raw citation counts).

Table 52 Top ten most cited publications, Engineering

Citations	RC	Title	Journal	DOI
349	29.3	SUDS, LID, BMPs, WSUD and more – The evolution and application of terminology surrounding urban drainage	Urban Water Journal	10.1080/1573062X.2014.916314
168	26.5	1 year, 1000 km: The Oxford RobotCar dataset	International Journal of Robotics Research	10.1177/0278364916679498
943	23.0	Review of bioactive glass: From Hench to hybrids	Acta Biomaterialia	10.1016/j.actbio.2012.08.023
327	21.8	Appearance-only SLAM at large scale with FAB-MAP 2.0	International Journal of Robotics Research	10.1177/0278364910385483
921	18.6	Biomedical photoacoustic imaging	Interface Focus	10.1098/rsfs.2011.0028
181	12.3	Terahertz quantum cascade lasers with >1 W output powers	Electronics Letters	10.1049/el.2013.4035
70	12.0	Vibration suppression of cables using tuned inerter dampers	Engineering Structures	10.1016/j.engstruct.2016.04.017
47	11.5	Optimal configurations for a linear vibration suppression device in a multi-storey building	Structural Control and Health Monitoring	10.1002/stc.1887
132	11.3	A review of volunteered geographic information quality assessment methods	International Journal of Geographical Information Science	10.1080/13658816.2016.1189556
173	9.8	Development of imidazolium-type alkaline anion exchange membranes for fuel cell application	Journal of Membrane Science	10.1016/j.memsci.2012.05.006

Note that the top 10 most cited publications are selected based on the ARC (not the raw citation counts).

Table 53 Top ten most cited publications, Information & Communication Technologies

Citations	RC	Title	Journal	DOI
782	56.7	Spatial modulation for generalized MIMO: Challenges, opportunities, and implementation	Proceedings of the IEEE	10.1109/JPROC.2013.2287851
726	46.4	BUBBLE Rap: Social-based forwarding in delay-tolerant networks	IEEE Transactions on Mobile Computing	10.1109/TMC.2010.246
203	38.2	HermiT: An OWL 2 Reasoner	Journal of Automated Reasoning	10.1007/s10817-014-9305-1
350	24.8	Performance comparison of MIMO techniques for optical	IEEE Transactions on Communications	10.1109/TCOMM.2012.120512.110578

		wireless communications in indoor environments		
219	23.2	A survey on platoon-based vehicular cyber-physical systems	IEEE Communications Surveys and Tutorials	10.1109/COMST.2015.2410831
532	16.9	OWL 2: The next step for OWL	Web Semantics	10.1016/j.websem.2008.05.001
213	15.1	Speech synthesis based on hidden Markov models	Proceedings of the IEEE	10.1109/JPROC.2013.2251852
190	14.2	Detection and Classification of Acoustic Scenes and Events	IEEE Transactions on Multimedia	10.1109/TMM.2015.2428998
164	13.3	A Tableau decision procedure for SHOIQ	Journal of Automated Reasoning	10.1007/s10817-007-9079-9
120	13.2	Tractable query answering and rewriting under description logic constraints	Journal of Applied Logic	10.1016/j.jal.2009.09.004

Note that the top 10 most cited publications are selected based on the ARC (not the raw citation counts).

Table 54 Top ten most cited publications, Mathematics & Statistics

Citations	RC	Title	Journal	DOI
135	28.4	Smoothing Parameter and Model Selection for General Smooth Models	Journal of the American Statistical Association	10.1080/01621459.2016.1180986
40	18.8	Breaking the coherence barrier: A new theory for compressed sensing	Forum of Mathematics, Sigma	10.1017/fms.2016.32
126	15.2	On particle methods for parameter estimation in state-space models	Statistical Science	10.1214/14-STS511
64	14.3	Higher order commutator estimates and local existence for the non-resistive MHD equations and related models	Journal of Functional Analysis	10.1016/j.jfa.2014.03.021
103	13.0	Wild binary segmentation for multiple change-point detection	Annals of Statistics	10.1214/14-AOS1245
41	12.4	Control functionals for Monte Carlo integration	Journal of the Royal Statistical Society. Series B: Statistical Methodology	10.1111/rssb.12185
109	11.6	NLEVP: A collection of nonlinear eigenvalue problems	ACM Transactions on Mathematical Software	10.1145/2427023.2427024
41	11.0	G2-Manifolds and associative submanifolds via semi-fano 3-folds	Duke Mathematical Journal	10.1215/00127094-3120743
32	10.7	The fourier transform for certain HyperKähler fourfolds	Memoirs of the American Mathematical Society	10.1090/memo/1139

98	10.6	Variable selection with error control: Another look at stability selection	Journal of the Royal Statistical Society. Series B: Statistical Methodology	10.1111/j.1467-9868.2011.01034.x

Note that the top 10 most cited publications are selected based on the ARC (not the raw citation counts).

Table 55 Top ten most cited publications, Physics & Astronomy

Citations	RC	Title	Journal	DOI
5182	204.9	Fine structure constant defines visual transparency of graphene	Science	10.1126/science.1156965
2780	132.5	Control of graphene's properties by reversible hydrogenation: Evidence for graphane	Science	10.1126/science.1167130
8652	87.5	Graphene: Status and prospects	Science	10.1126/science.1158877
1423	63.1	Chaotic dirac billiard in graphene quantum dots	Science	10.1126/science.1154663
470	41.6	Measuring the Chern number of Hofstadter bands with ultracold bosonic atoms	Nature Physics	10.1038/nphys3171
228	28.4	The second laws of quantum thermodynamics	Proceedings of the National Academy of Sciences of the United States of America	10.1073/pnas.1411728112
376	28.2	Commensurate-incommensurate transition in graphene on hexagonal boron nitride	Nature Physics	10.1038/nphys2954
552	26.3	Metamaterial with negative index due to chirality	Physical Review B - Condensed Matter and Materials Physics	10.1103/PhysRevB.79.035407
483	26.3	Integrated compact optical vortex beam emitters	Science	10.1126/science.1226528
329	26.1	Universal linear optics	Science	10.1126/science.aab3642

Note that the top 10 most cited publications are selected based on the ARC (not the raw citation counts).

Table 56 Top ten most cited publications with the RC>10, other disciplines

Discipline	Citations	RC	Title	Journal	DOI
Agriculture, Fisheries & Forestry	101	16.2	A dynamic model of bovine tuberculosis spread and control in Great Britain	Nature	10.1038/nature13529
Biology	258	17.5	Swarm: Robust and fast clustering method for amplicon-based studies	PeerJ	10.7717/peerj.593
Biomedical Research	219	24.1	Magnetite pollution nanoparticles in the human brain	Proceedings of the National Academy of	10.1073/pnas.1605941113

				Sciences of the United States of America	
	248	11.8	Combined quantum mechanics/molecular mechanics (QM/MM) methods in computational enzymology	Biochemistry	10.1021/bi400215w
	696	11.2	Accurate determination of microbial diversity from 454 pyrosequencing data	Nature Methods	10.1038/nmeth.1361
	165	10.7	Force Triggers YAP Nuclear Entry by Regulating Transport across Nuclear Pores	Cell	10.1016/j.cell.2017.10.008
	336	10.1	Pulsatile stimulation determines timing and specificity of NF-?B-dependent transcription	Science	10.1126/science.1164860
Earth & Environmental Sciences	326	14.1	Material efficiency: A white paper	Resources, Conservation and Recycling	10.1016/j.resconrec.2010.11.002
	109	12.3	The art and science of climate model tuning	Bulletin of the American Meteorological Society	10.1175/BAMS-D-15-00135.1
	267	11.6	What do we know about metal recycling rates?	Journal of Industrial Ecology	10.1111/j.1530-9290.2011.00342.x
Psychology & Cognitive Sciences	273	24.0	Knowing your own heart: Distinguishing interoceptive accuracy from interoceptive awareness	Biological Psychology	10.1016/j.biopsycho.2014.11.004
	410	13.2	Interoceptive inference, emotion, and the embodied self	Trends in Cognitive Sciences	10.1016/j.tics.2013.09.007
Public Health & Health Services	241	19.6	Spoofing and countermeasures for speaker verification: A survey	Speech Communication	10.1016/j.specom.2014.10.005
Social Sciences	143	26.4	Analysis of named entity recognition and linking for tweets	Information Processing and Management	10.1016/j.ipm.2014.10.006

Note that the top 10 most cited publications are selected based on the ARC (not the raw citation counts).

Appendix D Quotes from survey respondents

Table 57 Recommendations proposed by EPSRC alumni

Idea	Quote from EPSRC alumni
Open to all fields	*"In general try not to tie all fellowships to specific areas or initiatives. The next important breakthroughs won't necessarily arise on the path that everyone is following, but in a hitherto unexplored space."* Senior Fellowship *"I disagree with the decision to restrict Fellowships in the recent pasts to particular areas within a given discipline. I think this is misguided and causes EPSRC not to support the very strongest researchers."* Leadership Fellow *"An ongoing concern is the diversity (e.g. gender balance) of fellowship recipients. I hope that any changes to the balance of subjects permitted to apply for fellowships takes into account whether this unintentionally changes the gender balance. The gender balance of EPSRC fellowships determines gender balance of academic appointments."* Career Acceleration Fellow
Coverage of fellowship schemes across career stages	*"The fellowship schemes have been great for me personally and have been instrumental in me developing my research career. The random nature of different fellowship schemes being available and then not makes it hard to rely on these schemes…I would advise some-one in my position to pursue a Wellcome Fellowship over an EPSRC one at the moment as they can advance along this path."* Early Career Fellowship *"The current themes for established career fellowships are far too narrow, especially when compared to early career schemes. On starting my early career fellowship, I was hopeful that I might be able to continue my work in the longer term via a senior fellowship, but my field of research is not included in the very restrictive set of topics covered at established level…The justification for different themes being relevant to different career stages is not clear."* Early Career Fellowship *"…the fellowship priority areas are uneven across the career stages of the fellowships, which is impeding some very good science that would greatly benefit from a fellowship."* Career Acceleration Fellow
Eligibility criteria	*"Some boundaries in terms of career stage of those who should apply would be good, like years of independent research experience or similar. At the moment I feel like increasingly senior people are getting postdoc fellowships, crowding out the people who would benefit the most; similarly the "early career" stage is essentially reserved now for those who are almost at full professor level.* Postdoctoral Fellow (post 2011) *Since I had my fellowship, the Early Career fellowships have become eligible to researchers who already have permanent positions. To my mind that means a previously valuable route has been closed off to a generation of postdocs. They cannot realistically compete for the same funding as existing academics.* Career Acceleration Fellow
Offer of a permanent position	*"Make institutions commit to hiring fellows after the tenure of their fellowship."* Career Acceleration Fellow *"I think that the fact that there was no obligation to automatically hire me at the end of the fellowship was perversely a good thing, as that allowed the department to take a punt on me and other fellowship candidates it otherwise might not have done."* Career Acceleration Fellow

Table 58 Radical changes proposed by EPSRC alumni for the Fellowship scheme

Idea	Quote from EPSRC alumni

Abolish fellowships	"This will sound radical, but I would actually prefer if they were abolished altogether. Researchers can (in theory) request 100% FTE on standard grants anyway if they wish to focus entirely on a particular project. Fellowships are being abused by many institutions as a way to get free staff without making any long-term commitment to them." Postdoctoral Fellow (pre 2011)
Provide less money	"Many thanks to the EPSRC for setting me off on the direction I'm on now. However, I'm concerned with the inequity of giving a small group of people a lot of money and having lots of losers. I am horrified by the UKRI programme, and I'm sitting on ERC panels for starting grants and I'm very concerned that we're producing monsters in terms of powerful PI that are getting the Matthew Effect [the rich get richer and the poor get poorer]. I thought that it would be better to give people £300K for 2 years with close mentorship, than give the rest. That will allow many more people to participate in the starting stages. I'm a beneficiary of such fellowship schemes and still, I am concerned of what this does to ECRs." Challenge Engineering Fellow
Abolish fellowship extensions	"Throwing more money after good" - fellowship extensions - are probably an easy way to spend money usefully (and I was very pleased to have an extension), but it would probably be better used to fund new fellowships. Five years is a very nice period to have, but shorter fellowships would also be useful; I think more, shorter, fellowships would be better." Leadership Fellow
Create an elite fellowship	"You should consider adding a German Humboldt style one (£5m) to attract world leading scientists to the UK (3-5 annually). And if indeed the UK disappears from the ERC, these are going to become much, much, much, much more important. It is really only these grants that enable long term planning and freedom to make serious breakthroughs. £300k single postdocs responsive mode grants are 'projects' - and clearly have their place, but these fellowships are what start and make careers through real breakthroughs. And the bigger ones are very high profile, which sends an important message (we get the best people, rather than - we can't afford them) - that's what the Humboldt Professorships did for German Science. And it is not expensive in the grand scheme of things (£20m/yr)." Career Acceleration Fellow
Replicate the ERC fellowship schemes	"Bring in schemes that mimic the ERC schemes and make them available to international applicants. Have them up and running in time for Brexit." Leadership Fellow

Table 59 Feedback from EPSRC alumni, by fellowship type

"Freedom, time, money, reduction in other workloads. This is the best scheme out there for early academics. Basically provides a US-elite start up package, but protects from 'all the stuff'. In my opinion this is not sufficiently highlighted. We could/should attract the very best people in the world with this scheme. Important to clarify that this is 'effectively' a US tenure process. If things go well, one gets a job. If not, one doesn't. Whether it is officially tenure track or not really is irrelevant.

Career Acceleration Fellow

"The Challenging Engineering scheme was transformational. It helped raise the profile of engineering and the fellowship holders have gone on to become leaders in their respective fields. This scheme was exceptionally good value for money and should be held up as an example of how a relatively small investment can truly build tomorrow's leaders."

Challenge Engineering Fellow

"The great benefit of these fellowships, over say fellowships at the UKRI level, is that they really value depth of science. It is this subject-specific depth which means that the EPSRC fellowships have the really big impact in the long term, and it also is easier to communicate vision at the subject level. The UKRI fellowships are more elevator-pitch centric, both in order to get past institutional-level demand management and at the more generalist panels, who are often just unable to judge the depth and long term impact. So, for researchers who really want to leave their mark on the subject, I very much recommend the EPSRC fellowship route."

Early Career Fellow

"This is by far the most impactful and beneficial scheme in establishing a research career and I also feel this is what makes the UK academia distinct and attractive. I could not support the fellowship schemes stronger."

Engineering for Growth Fellow

I am massively grateful for the opportunity which has not only helped my career, but has also impacted on the lives on many more people around me - e.g., [other staff in the department], my research group (PhD students, postdocs and development engineers) and [employees from my spinout]…

Established Career Fellow

"I participated to an EPSRC Leadership fellowship. Unfortunately, it no longer exists. It covered a career stage in between the early career and the established one. I personally thought it was a great scheme, back then it would have been too early for me to try an established fellowship and probably too late for the early career. The Leadership fellowship was perfect for my career stage and it really boosted my progression forward both scientifically and career wise."

Leadership Fellow

"Without the manufacturing fellowships scheme I would not have made the move from industry. I am currently in conversation with an industrialist who is contemplating this move in the absence of the scheme and it is less attractive."

Manufacturing Fellow

"I see the post-doctoral fellowship as having been critical to my career in academia. It allowed me to develop the skills needed to secure a permanent academic position, as well as a proper presence in my field, in a way which would not have been possible in a normal post-doctoral research role."

Postdoctoral Fellow (post 2011)

"Early career and postdoctoral fellowships are invaluable for mathematics, having a disproportionately large impact compared to more established career fellowships since they give young people the time needed to establish a research programme."

Postdoctoral Fellow (pre 2011)

"The Senior Fellowship scheme allowed a few academics the freedom to think out of the box and drive fundamentally new research. It was a very special scheme. I was very disappointed when it was discontinued/mothballed."

Senior Fellowship

Appendix E Assumptions to economic modelling

E.1. Wage premium

Table 60 Assumptions – Wage premium

The EPSRC fellowship programme is a prestigious programme that offers fellows an opportunity to acquire additional knowledge and experience and offers fellows an opportunity to advance their career. This career advancement is anticipated to have an impact on the fellows current and future salary.

CORE ASSUMPTION: It is assumed that all fellows will benefit from a wage premium. Drawing on the results from a survey to EPSRC Fellowship alumni (see the table below), the wage premium is assumed to amount to 1.04%. Any additional salary increases are not attributable.

Alumni will benefit from a wage premium that is earned on top of the base salary. Annual average wages per age bracket for scientific careers are assumed (ONS, 2019)[25]. ONS salary data suggests salary increases with age until 50-59 and then drops.

It is assumed that the fellows/alumni will benefit from a wage premium over the remainder of their career, from the start of the fellowship until they retire at age 61.

Wage premium calculations consider:

- The estimated average age of fellows, by fellowship type
- The estimated number of years the average fellow/alumni 'spends' in each age bracket, by fellowship type
- The number of fellowships awarded, by fellowship type
- The average wage based on statistics for 2019, by age bracket
- The estimated value of the total accumulated wage
- The estimated wage premium

Inflation, mortality and other factors are ignored.

Table 61 Survey results- What happened to your salary in immediately after the end of your fellowship compared to your salary during the fellowship

Response	Value	Number of respondents	Percentage of respondents	Weighted
My salary increased by more than 4%	0.05	47	22%	1.10%
My salary decreased by less than 2%	-0.02	3	1%	-0.03%
My salary decreased by more than 4%	-0.05	10	5%	-0.23%
My salary increased by up to 2%	0.02	10	5%	0.09%
My salary increased by between 2% - 4%	0.03	9	4%	0.13%
My salary decreased by between 2% - 4%	-0.03	1	0%	-0.01%
My salary stayed the same	0	134	63%	0.00%
Total	0	214	100%	1.04%

Table 62 Estimated years per age bracket and fellowship type

		Estimated years per age bracket

[25] ONS (2019) https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/datasets/agegroupbyindustry2digitsicashetable21

	Average assumed age	22-29	30-39	40-49	50-59	60+
Post Doc - Post 2011	30	0	10	10	10	2
Post Doc - Pre 2011	30	0	10	10	10	2
Career Acceleration	35	0	5	10	10	2
Early Career	35	0	5	10	10	2
Senior Fellowships	50	0	0	0	10	2
Leadership	50	0	0	0	10	2
Established Career	50	0	0	0	10	2
Challenging Engineering	40	0	0	10	10	2
Manufacturing	40	0	0	10	10	2
Engineering for Growth	40	0	0	10	10	2

Table 63 Scientific research and development annual pay (average), by age bracket

	22-29	30-39	40-49	50-59	60+
Estimated wage per age bracket	£31,481	£38,686	£51,828	£62,971	£38,658

Source: ONS (2019) Gross earnings

Table 64 Estimated wage premium, by fellowship

	Number of fellows	Wage per fellow	Wage premium Per fellow	Total estimated wage premium
Post Doc - Post 2011	53	£1,612,166	£16,800	£890,383
Post Doc - Pre 2011	158	£1,612,166	£16,800	£2,654,348
Career Acceleration	107	£1,418,736	£14,784	£1,581,891
Early Career	105	£1,418,736	£14,784	£1,552,323
Senior Fellowships	18	£707,026	£7,368	£132,617
Leadership	69	£707,026	£7,368	£508,365
Established Career	43	£707,026	£7,368	£316,807
Challenging Engineering	37	£1,225,306	£12,768	£472,430
Manufacturing	3	£1,225,306	£12,768	£38,305
Engineering for Growth	10	£1,225,306	£12,768	£127,684
Total	**603**			**£8,275,152**
Average				**£13,723**

E.2. Spinouts

Table 65 Assumptions – Spinouts

The EPSRC programme has contributed to the creation/development of spinouts. To date, 50 EPSRC fellowships from 2006-2017 contributed to the creation/development of 40 spinouts, as recorded in Researchfish. Some EPSRC grants contributed to the creation/development of more than one spinout and some spinouts benefitted from the inputs of more than one EPSRC fellow.

The 40 spinouts were launched from 2006-2016, over a period of 11 years. On average, 3 spinouts were launched per year.

It is assumed that the GVA of the spinouts created/developed are partially attributable to the EPSRC programme.

CORE ASSUMPTION: it is assumed that the proportion of EPSRC funding that made the creation/development of spinouts possible reflect the value of the EPSRC investment. Spinouts are assigned a weight considering the grant source (EPSRC and other). Spinouts that are only linked to the EPSRC fellowship programme are given the weight 1 and spinouts that are linked to multiple grant programmes are given a lower weight reflecting the proportion of co-funding (e.g. 0.5 for 50% EPSRC funding). The sum of the (EPSRC related) weight across the 40 spinouts amounts to 33.4, 3.0 on average.

CORE ASSUMPTION: it is assumed that university spinouts have 70% higher survival rates than the average start-ups and that, as a result of the higher survival rates, the portfolio of spinouts yields a right than average GVA return. This higher than average approximate Gross Value Added (GVA) return is attributed to the EPSRC programme.

CORE ASSUMPTION: it is assumed that the spinouts have a 70% higher survival rate for the life of the firm, up to the maximum age 50.

CORE ASSUMPTION: it is assumed that the net present value (NPV) of the spinouts at the year of birth, in 2019 prices can be calculated using a 2% discount rate

The calculations to estimate the average GVA of spinouts, by firm age, consider:

- GVA per worker by per firm age, based on statistics from 2007-2017 (ONS)
  - Data are available for firms aged 0-12 and 13+. GVA for firms aged 6+ is assumed the average of GVA for firms 6-12 & 13+
- Average number of workers by firm age based on statistics for the UK from EUROSTAT - data for 2009-2017.
  - Data are available for firms aged 0 to 5 as well as the average total (firms of all ages). For firms aged 6+ the average number of workers are assumed equal to the average total minus the sum of the average number of workers for firms aged 0 to 5.
- Average GVA for 2007-2018, by firm age. This is calculated based on data on GVA per worker and data on the average number of workers

The calculations to estimate the average survival rates of spinouts, by firm age, consider:

- Average survival rate for 2007-2018, by firm age. This is calculated based on data on the survival rate of firms (by firm age) using statistics for the UK from EUROSTAT.
  - Data are available for firms aged 0 to 5 as well as the average total (firms of all ages). For firms aged 6+ the survival rates are assumed equal to the average total minus the sum of the average number of workers for firms aged 0 to 5.
  - The survival rate series has a 'break' after age 5 and average statistics for firms aged 6+ are aggregated. To address this 'break', it is assumed that the trend is linear from age 6 to the average survival rate of firms aged 6+.

The calculations to estimate the additional GVA of university spinouts consider:

- Number of number of additional firms that survive compared with the statistics for the average firm (counterfactual), by age (see Table 67)
- The estimated GVA by, age (see Table 67)
- The maximum lifetime of a firm, which is assumed 50
- The total net additional GVA, based on data on the average number of spinouts multiplied by the average spinout net additional GVA

CORE ASSUMPTION: To estimate the **total GVA of spinouts** for the total portfolio of research funded, it is assumed that for 2007-2018, on average, 3.0 spinouts were launched per year. The best estimate corrects for an impact/reporting lag. In 3 of 14 years (2017- 2019) in which the EPSRC fellowship was running there were no spinouts.

Table 66 Estimated additional GVA of spinouts

	Results	**Note to calculations**
A. Total university spinouts, after correcting for co-funding	33.4	
B. Additional NPV of the spinout GVA at year of birth (2019 prices)	£249,467,378	[see Table 67]
C. Average additional NPV of the spinout GVA at year of birth (2019 prices)	£7,461,290	[B / A]
D. Average number of spinouts per year (2007-2018)	3.0	[A / 11 years]
E. Total additional NPV of the spinout GVA at year of birth (2019 prices), correcting for impact/reporting lag	£317,503,936	[D x 14 years x C]

Table 67 Estimated additional NPV of spinouts

firm age	**GVA per firm (£000)**	**GVA (extrapolate)**	**Survival rates**	**Survival rate (smooth extrapolate**	**Remaining (contrafactual)**	**Survival rates (treated)**	**Remaining (treated)**	**Additional firms**	**Additional GVA**
0	£89	£89	100.0	100.0	33.4	100.0	33.4	0.0	£0
1	£121	£121	89.9	89.9	30.1	100.0	33.4	3.4	£409,622
2	£137	£137	73.1	73.1	22.0	100.0	33.4	11.5	£1,567,130
3	£178	£178	57.8	57.8	12.7	98.3	32.9	20.2	£3,590,088
4	£197	£197	48.0	48.0	6.1	81.5	26.8	20.7	£4,085,666
5	£229	£229	40.6	40.6	2.5	69.0	18.5	16.0	£3,672,105
6	£764	£256	92.7	48.0	1.2	81.5	15.1	13.9	£3,554,416
7	£764	£283	92.7	57.8	0.7	98.3	14.8	14.1	£4,010,368
8	£764	£311	92.7	73.1	0.5	100.0	14.8	14.3	£4,460,829
9	£764	£339	92.7	89.9	0.5	100.0	14.8	14.4	£4,876,085
10	£764	£367	92.7	92.7	0.4	100.0	14.8	14.4	£5,287,572
11	£764	£395	92.7	92.7	0.4	100.0	14.8	14.4	£5,699,940
12	£764	£422	92.7	92.7	0.4	100.0	14.8	14.5	£6,113,064
13	£764	£450	92.7	92.7	0.3	100.0	14.8	14.5	£6,526,831
14	£764	£478	92.7	92.7	0.3	100.0	14.8	14.5	£6,941,143
15	£764	£506	92.7	92.7	0.3	100.0	14.8	14.5	£7,355,911
16	£764	£533	92.7	92.7	0.3	100.0	14.8	14.6	£7,771,057
17	£764	£561	92.7	92.7	0.2	100.0	14.8	14.6	£8,186,512

18	£764	£589	92.7	92.7	0.2	100.0	14.8	14.6	£8,602,214
19	£764	£617	92.7	92.7	0.2	100.0	14.8	14.6	£9,018,109
20	£764	£644	92.7	92.7	0.2	100.0	14.8	14.6	£9,434,150
21	£764	£672	92.7	92.7	0.2	100.0	14.8	14.7	£9,850,295
22	£764	£700	92.7	92.7	0.2	100.0	14.8	14.7	£10,266,508
23	£764	£728	92.7	92.7	0.2	100.0	14.8	14.7	£10,682,757
24	£764	£756	92.7	92.7	0.1	100.0	14.8	14.7	£11,099,015
25	£764	£764	92.7	92.7	0.1	100.0	14.8	14.7	£11,229,432
26	£764	£764	92.7	92.7	0.1	100.0	14.8	14.7	£11,236,920
27	£764	£764	92.7	92.7	0.1	100.0	14.8	14.7	£11,243,865
28	£764	£764	92.7	92.7	0.1	100.0	14.8	14.7	£11,250,305
29	£764	£764	92.7	92.7	0.1	100.0	14.8	14.7	£11,256,278
30	£764	£764	92.7	92.7	0.1	100.0	14.8	14.7	£11,261,817
31	£764	£764	92.7	92.7	0.1	100.0	14.8	14.8	£11,266,955
32	£764	£764	92.7	92.7	0.1	100.0	14.8	14.8	£11,271,719
33	£764	£764	92.7	92.7	0.1	100.0	14.8	14.8	£11,276,138
34	£764	£764	92.7	92.7	0.1	100.0	14.8	14.8	£11,280,236
35	£764	£764	92.7	92.7	0.1	100.0	14.8	14.8	£11,284,037
36	£764	£764	92.7	92.7	0.1	100.0	14.8	14.8	£11,287,562
37	£764	£764	92.7	92.7	0.1	100.0	14.8	14.8	£11,290,831
38	£764	£764	92.7	92.7	0.1	100.0	14.8	14.8	£11,293,863
39	£764	£764	92.7	92.7	0.0	100.0	14.8	14.8	£11,296,675
40	£764	£764	92.7	92.7	0.0	100.0	14.8	14.8	£11,299,282
41	£764	£764	92.7	92.7	0.0	100.0	14.8	14.8	£11,301,701
42	£764	£764	92.7	92.7	0.0	100.0	14.8	14.8	£11,303,944
43	£764	£764	92.7	92.7	0.0	100.0	14.8	14.8	£11,306,024
44	£764	£764	92.7	92.7	0.0	100.0	14.8	14.8	£11,307,953
45	£764	£764	92.7	92.7	0.0	100.0	14.8	14.8	£11,309,742
46	£764	£764	92.7	92.7	0.0	100.0	14.8	14.8	£11,311,402
47	£764	£764	92.7	92.7	0.0	100.0	14.8	14.8	£11,312,941

48	£764	£764	92.7	92.7	0.0	100.0	14.8	14.8	£11,314,368
49	£764	£764	92.7	92.7	0.0	100.0	14.8	14.8	£11,315,692
50	£764	£764	92.7	92.7	0.0	100.0	14.8	14.8	£11,316,919
NPV (2% discount)									£317,503,936

E.3. Patents

Table 68 Assumptions – Patents

To date, the EPSRC programme has contributed to the development of patentable solutions. 35 patents were granted that partially attributable to the EPSRC programme, based on data recorded in Researchfish. It is assumed that the value of those patents are also partially attributable to the EPSRC programme.

The 35 granted patents are attributable to 42 grants, 37 are EPSRC Fellowship programme grants.

CORE ASSUMPTION: it is assumed that granted patents have 5% higher value. This premium is attributed to the EPSRC programme.

CORE ASSUMPTION: it is assumed that the proportion of EPSRC funding that made the development of patentable solutions possible reflect the value of the EPSRC investment. Granted patents are assigned a weight taking into account the grant source (EPSRC and other). Granted patents that are only linked to the EPSRC fellowship programme are given the weight 1 and granted patents that are linked to multiple grant programmes are given a lower weight reflecting the proportion of co-funding (e.g. 0.5 for 50% EPSRC funding). The sum of the (EPSRC related) weight across the 35 patents amounts to 32.9.

CORE ASSUMPTION: it is assumed that the value of the granted patents that are linked to EPSRC Fellowship funding can be estimated using data from a survey to UK investors as a benchmark. The total and average value patents is calculated using data from a survey to UK investors (Patval, 2007), taking into account the distribution of the value of patents.

CORE ASSUMPTION: It is assumed that the **lower bound total patent value** is equal to the average additional value of a patent, £484k, multiplied by the total number of granted patents that are linked to the EPSRC Fellowship (ie 32.9, after correcting for co-funding).

Table 69 PatVal Survey results from UK inventors – granted patents

Mid-point (€, 2004)	Mid-point (£, 2004)	Mid-point (£, 2019)	% of UK patents	Assumed dist. of EPSRC patents	Est. value of patents (£, 2019)
15k	10,181	14,347	4.82%	1.59	22,742
65k	44,116	62,166	10.82%	3.56	221,212
200k	135,740	191,278	15.79%	5.19	993,288
650k	441,156	621,655	22.30%	7.33	4,559,134
2m	1,357,402	1,912,783	22.88%	7.52	14,392,949
6.5m	4,411,557	6,216,547	12.28%	4.04	25,105,886
20m	13,574,020	19,127,835	5.56%	1.83	34,975,873
65m	44,115,565	62,165,463	3.44%	1.13	70,329,183
200m	135,740,200	191,278,347	1.02%	0.34	64,164,371

300m	203,610,300	286,917,521	1.10%	0.36	103,795,305
Total				32.9	318,559,942

Source: Patval survey. (2007) Value of UK patents: https://www.researchgate.net/publication/222816523_Inventors_and_Invention_Processes_in_Europe_Results_from_the_PatVal-EU_Survey. Note: The final category (€300m+) has no mid-point and so a minimum value (€300m) was used instead; The mid-points have been converted from € to £ based on 2004 exchange rates (0.678701); 2004 prices inflated to 2019

Table 70 Estimated value of patents

	Results	Note to calculations
A. Total number of granted patents, after correcting for co-funding	32.9	
B. Total value of granted patents	£318,559,942	
C. Average value per patent granted	£9,686,418	[B / C]
D. Additional value	5%	
E. Average value per patent	£484,321	[B x D]
F. Average number of granted patents per year (2007-2015)	3.7	
G. Total additional value of granted patents, correcting for impact/reporting lag	£24,776,884	[G x E x 14]

E.4. Spillovers

Table 71 Assumptions – Spillovers

The research activities carried out by EPSRC fellows is thought to impact other stakeholders. A trail of knowledge transfer can be captured using the citation references made by stakeholders to publications that are linked to the EPSRC Fellowship. The benefits of these knowledge transfer is captured using data to estimate the value of the patents that have cited fellows' publications. There are 414 publications that can be attributed to the EPSRC fellowship that are referenced by 1,012 patents. **CORE ASSUMPTION:** it is assumed that the proportion of EPSRC funding that made the publication outputs possible reflect the value of the EPSRC investment. Patents are assigned a weight taking into account the publications' grant source (EPSRC and other). Patents that cite a publication that was made possible only in part because of the EPSRC grant are given a lower weight reflecting the proportion of co-funding (e.g. 0.5 for 50% EPSRC funding). Publications that are only linked to EPSRC Fellowship funding are given the weight 1. The sum of the weight across the 1,012 patents amounts to 855.7. **CORE ASSUMPTION:** it is assumed that the value of the patents that cited publications that are linked to EPSRC Fellowship funding can be estimated using data from a survey to UK investors as a benchmark. The total and average value patents is calculated using data from a survey to investors (Patval, 2007), taking into account the distribution of the value of patents. **CORE ASSUMPTION:** the estimated value of the portfolio of patents that can be attributed to the EPSRC fellowship is a factor of the median number of **Non-Patent-Literature** (NPL) citations of the portfolio of patents, which is 27. The median NPL Resolved Citation Count is an indicator for the number of publications that are cited by a given patent. • This means that 3.7% of the patent value is attributed to a publication linked to the EPSRC Fellowship, after correcting for co-funding. Note that the NPL citation count is sometimes used as an indicator value or quality of a patent; patents with a high NPL are shown to contain more complex and fundamental knowledge. **CORE ASSUMPTION:** It is assumed that the **lower bound total spillover** is equal to the average additional value of a patent, £358.8k, multiplied by the total number of patents that cited publications that are linked to the EPSRC Fellowship (ie 855.7, after correcting for co-funding).

<u>CORE ASSUMPTION:</u> To estimate the **total spillover effect** for the total portfolio of research funded, it is assumed that for 2006-2019, on average, 99 patents cite publications that are linked to the EPSRC Fellowship, adding £358.8k in additional value per patent. The best estimate corrects for an impact/reporting lag.

Table 72 PatVal Survey results from UK inventors – spillovers

Patent Value (€)	Mid-point (€, 2004)	Mid-point (£, 2004)	Mid-point (£, 2019)	% of all patents	Assumed dist. of EPSRC patents	Est. value of patents (£, 2019)
<30k	15k	10,181	14,347	7.88%	67.42	967,311
30-100k	65k	44,116	62,166	17.40%	148.86	9,254,280
100-300k	200k	135,740	191,278	20.65%	176.67	33,793,545
300k-1m	650k	441,156	621,655	21.80%	186.49	115,934,706
1-3 m	2m	1,357,402	1,912,783	15.46%	132.31	253,082,571
3-10m	6.5m	4,411,557	6,216,547	9.58%	81.99	509,700,757
10-30m	20m	13,574,020	19,127,835	3.70%	31.67	605,793,978
30-100m	65m	44,115,565	62,165,463	2.00%	17.10	1,063,305,631
100-300m	200m	135,740,200	191,278,347	0.76%	6.51	1,245,360,442
300m+	300m	203,610,300	286,917,521	0.77%	6.62	1,899,702,368
Total					**855.7**	**5,736,895,589**

Source: Patval survey. (2007) Value of UK patents: https://www.researchgate.net/publication/222816523_Inventors_and_Invention_Processes_in_Europe_Results_from_the_PatVal-EU_Survey. Note: The final category (€300m+) has no mid-point and so a minimum value (€300m) was used instead; The mid-points have been converted from € to £ based on 2004 exchange rates (0.678701); 2004 prices inflated to 2019

Table 73 Estimated spillovers due to knowledge transfer

	Results	Note to calculations
A. Total number of granted patents, after correcting for co-funding	855.7	
B. Total value of granted patents	£8,288,314,985	
C. Average value per granted patent	£ 9,686,418	[B / C]
D. Median number of NPL per granted patent	27	
E. Average additional value per granted patent	£358,756	[C / D]
F. Average number of granted patents per year (2008-2015)	99	
G. Total additional value of granted patents, correcting for impact/reporting lag	£477,516,090	[F x E x 14]

E.5. Displacement, substitution and deadweight

An outline of the approach to attributing benefits is presented in the table below.

Table 74 Approach to attributing impact

Approach to attributing impact	
Displacement	
Definition	Positive outcomes promoted by government policy are offset by a negative outcome of the same policy elsewhere
Context	EPSRC fellows are given an opportunity to boost their career which would make them more competitive candidates for other/future grants, enabling them to leverage additional funding and possibly displacing other research efforts. Displacement is likely to be high. EPSRC applicants that are not successful spent time and effort on applying for the EPSRC grant that could have been spent on their research and/or applying for other grants.
Approach	Data on the success rate of applying to the EPSRC fellowship Programme.
Substitution	
Definition	The effects of an intervention on a particular individual, group or area are (only) realised at the expense of other individuals, groups or areas
Context	EPSRC fellows may receive preferential treatment at their host institutions as a result of having been awarded the fellowship
Approach	Assessment based on survey data
Deadweight	
Definition	The policy supports outcomes which would have occurred anyway
Context	It is likely that without the grant, EPSRC fellows would still be able to pursue (some of) their research interests, drawing from other grants and income
Approach	Assessment based on survey data

Table 75 Assumptions – Displacement, substitution and deadweight

Research efforts of EPSRC Fellowship applicants that were not successful in their application are assumed to be displaced. Monitoring data on the total number of applications, and the total number invited to the final stage of application is used to calculate success rates and displacement rates.

Displacement 1:

CORE ASSUMPTION: It is assumed that the percentage of EPSRC Fellowship applicants that are rejected after the interview round are potentially displaced. **Displacement is assumed to be 49%.**

On the one hand, this is an upper bound measure because it is quite likely that many/most researchers find alternative sources of funding. One the other hand, the total number of EPSRC Fellowship applicants that are not successful in their application are considered the displacement figure is 75%, and in comparison 49% is a conservative estimate.

Displacement 2:

Unsuccessful applicants time and effort in applying for the EPSRC is displaced. From the 2,425 applicants, 1,822 are not successful. Average salaries by age bracket are used to place a cost on the time and effort spent by unsuccessful applicants. It is assumed that the application process involves five days' work per applicant. 261 working days per year are assumed. The total cost of time and effort spent by unsuccessful applicants is assumed £1.4m.

Table 76 Overview of potential displacement [1]

	Total number of applicants	Applicants interviewed	Successful applicants	Displacement – considering applicants interviewed	Displacement – considering total applicants
Post Doc - Post 2011	241	78	53	32%	78%
Post Doc - Pre 2011	910	292	158	46%	83%
Career Acceleration	225	221	107	52%	52%
Early Career	379	182	105	42%	72%
Senior Fellowships	146	33	18	45%	88%
Leadership	172	172	69	60%	60%
Established Career	117	75	43	43%	63%
Challenging Engineering	199	86	37	57%	81%
Manufacturing	9	9	3	67%	67%
Engineering for Growth	27	27	10	63%	63%
Total	**2,425**	**117,500**	**603**	**49%**	**75%**

Table 77 Overview of potential displacement [2]

	Average estimated age	Estimated wage	Cost of 5 days / 261 working days	Number of unsuccessful applicants	Displaced time and effort
Post Doc - Post 2011	30	£36,388	£697	188	£131,053
Post Doc - Pre 2011	30	£36,388	£697	752	£524,210
Career Acceleration	35	£36,388	£697	118	£82,256
Early Career	35	£36,388	£697	274	£191,002
Senior Fellowships	50	£47,479	£910	128	£116,424
Leadership	50	£47,479	£910	103	£93,685
Established Career	50	£47,479	£910	74	£67,307
Challenging Engineering	40	£45,493	£872	162	£141,185
Manufacturing	40	£45,493	£872	6	£5,229
Engineering for Growth	40	£45,493	£872	17	£14,816
Total				**£1,822**	**£1,367,167**

Table 78 Assumptions – Substitution

Substitution – is captured using data from a survey to alumni. Survey question: If some, or all, of your teaching load was transferred to another researcher/s for the duration of your Fellowship, please indicate how many teaching hours were transferred on average per week?

- 0 hours
- Up to 4 hours
- 5-8 hours
- 9-16 hours
- More than 16 hours

The estimated percentage of substitution was calculated based on the average number of hours transferred as a percentage of the number of hours in a typical working week, which is assumed to be 40 hours. The survey results suggest that, on average, 3.04 hours were transferred to other researchers, which results in a substitution effect of 7.6%.

Table 79 Survey results – substitution effect

Categories	Hours	Agree/ strongly agree	No transfer [not applicable /disagree/ strongly disagree	Number of respondents	Percentage of respondents	Weighted
Don't know	*[Not considered]*	11	0	0	0.0%	—
Up to 4 hours	4	35	0	35	18.4%	0.74
9-16 hours	12.5	13	0	13	6.8%	0.86
0 hours	0	4	102	106	55.8%	0.00
5-8 hours	6.5	32	0	32	16.8%	1.09
More than 16 hours	17	4	0	4	2.1%	0.36
Total		**99**	**102**	**190**	**100.0%**	**3.04**

Note: Considered 0 hours for those who disagreed / strongly disagreed to the item 'My teaching load was reduced by transferring some to another researcher/s', and dropped those who did not answer / don't know the weekly hours.

Table 80 Assumptions – Deadweight

Deadweight – is captured using data from a survey to alumni

Survey question: To what extent did the fellowship provided you with opportunities that you would not have had access to otherwise?

The sub-question 'time for research' is used as the component for calculating deadweight. The average response is calculated [0-5]. An overage of '5' indicates 0% deadweight and an average of '0' suggests 100% deadweight. The results from the survey indicate that the deadweight amounts to 11.6%.

Table 81 Survey results - deadweight

Time for research	Number of respondents	Percentage of respondents	Score	Deadweight - score	Deadweight - %
5 (totally)	124	59%	0	2.9	0.0

4	67	32%	20	1.3	6.41
3	11	5%	40	0.2	2.1
2	6	3%	60	0.1	1.7
1	0	0%	80	0.0	0.0
0 (not at all)	3	1%	100	0.0	1.4
Total	**211**	**100%**	**Weighted average**	**4.4**	**11.6%**

E.6. Total benefits

Table 82 Assumptions – total benefit

CORE ASSUMPTION: It is assumed that the **lower bound total benefit** of the Fellowship programme is the sum or the wage premium to the EPSRC fellowship alumni, the value of spinouts and patents that is attributed to the Fellowship programme and the spillover effects on other stakeholders.

Other benefits that may be realised through the fellowship programme are ignored.

The calculated benefits are based on data for a sample of fellowships, based on self-reported data in Researchfish. Data for a number of fellowships are missing.

The upper bound total benefit of the Fellowship programme is calculated by grossing-up the lower bound total benefit.

CORE ASSUMPTION: It is assumed that the alumni that have not reported to Researchfish perform, on average, just as well as the alumni that have reported to Researchfish. 20 of 603 fellows (3%) have not reported to Researchfish. The total benefit is grossed-up by 3%

Other potential underreporting and overreporting is ignored.

E.7. Costs

Table 83 Assumptions – Costs

CORE ASSUMPTION: It is assumed that the total costs of the fellowship are equal to the (reporting) value of the fellowships plus the value of co-funding.

The reporting value of fellowships amounts to (close to) £400m.

The value of (co-funding for 39 of 603 fellowships) amounts to £43.4m.

The cost of running the fellowship programme, promoting the programme, and monitoring and evaluation costs are ignored.

Appendix F Sensitivity analysis to the RoI modelling

In the sensitivity analysis the key assumptions made in the modelling are modified to estimate the impact of each assumption on the total estimated benefits (before adjusting for displacement, substitution etc.). The figures bellow show the results of the sensitivity analysis changing each parameter while keeping the other parameters constant.

One of the assumptions made in the analysis is that fellows benefit from a wage premium. The effect of the 1.04% assumed premium is compared to that of no premium, a 2% premium, 3 %, up to 6% premium. The results show that the effect of the wage premium on the return on investment is marginal. The difference between a wage premium of 0% (no wage premium) and 6% (a wage premium significantly higher than the one we are assuming in the RoI) is less than £50m. In the scenario of 0% wage premium, the total net benefits remain positive (£421m).

To calculate the estimated spinout additional GVA, the modelling assumes a 70% survival rate premium for the life of the life (up to 50 years). If the likelihood of survival rate is assumed 60%, the total net benefits would be of £347m, while a survival rate of 80% would accrue £388m in net benefits. Even in the scenario where there would be no spinout additionality (survival premium of 0%), the final total net benefits would remain positive.

The estimations around the patent value are sensitive to the assumed 5% additionality parameter, but these estimations do not have the power to cause the return on investment figures to result negative.

The knowledge spillovers component of the RoI can have a substantial impact on the end results. On the one hand, if a 2% attribution rate is assumed (rather than the 3.7%) the total net befits fall to £209m, while with a 4% attribution rate the total net benefits are of £467m — a sizeable variation. At a 1% attribution rate the total net benefits remain positive, but become negative if one assumes no knowledge spillovers at all (a 0% attribution rate).

Figure 45 Sensitivity analysis - wages

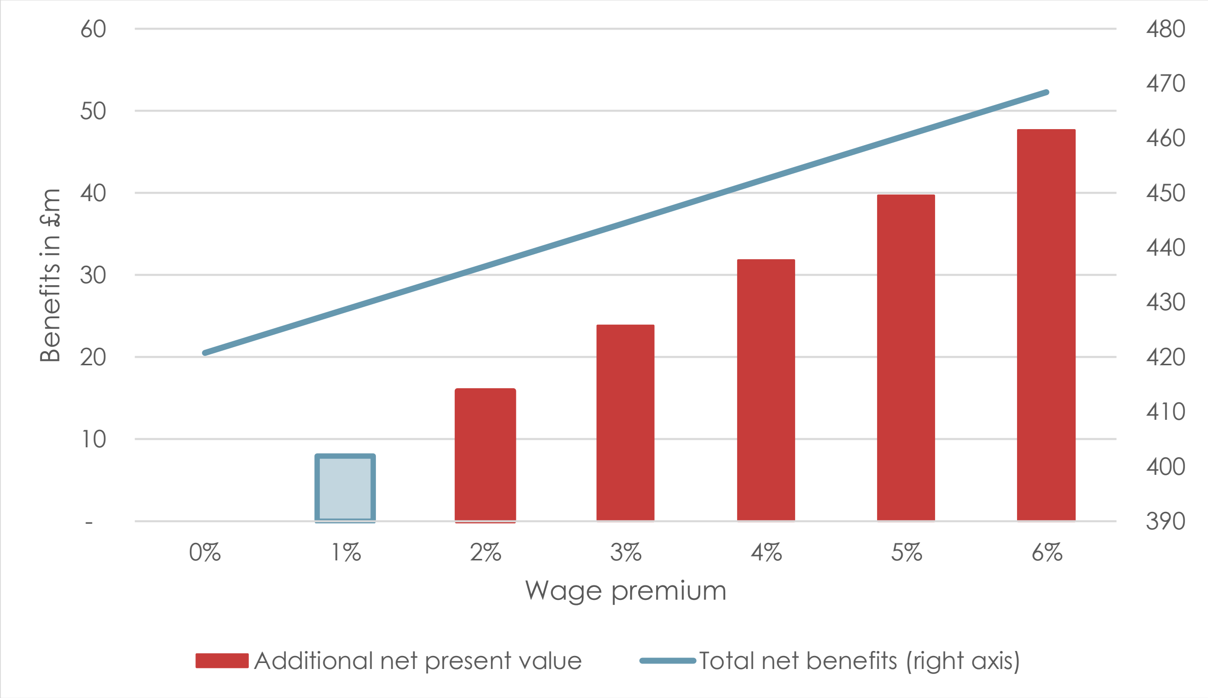


Figure 46 Sensitivity analysis - spinouts

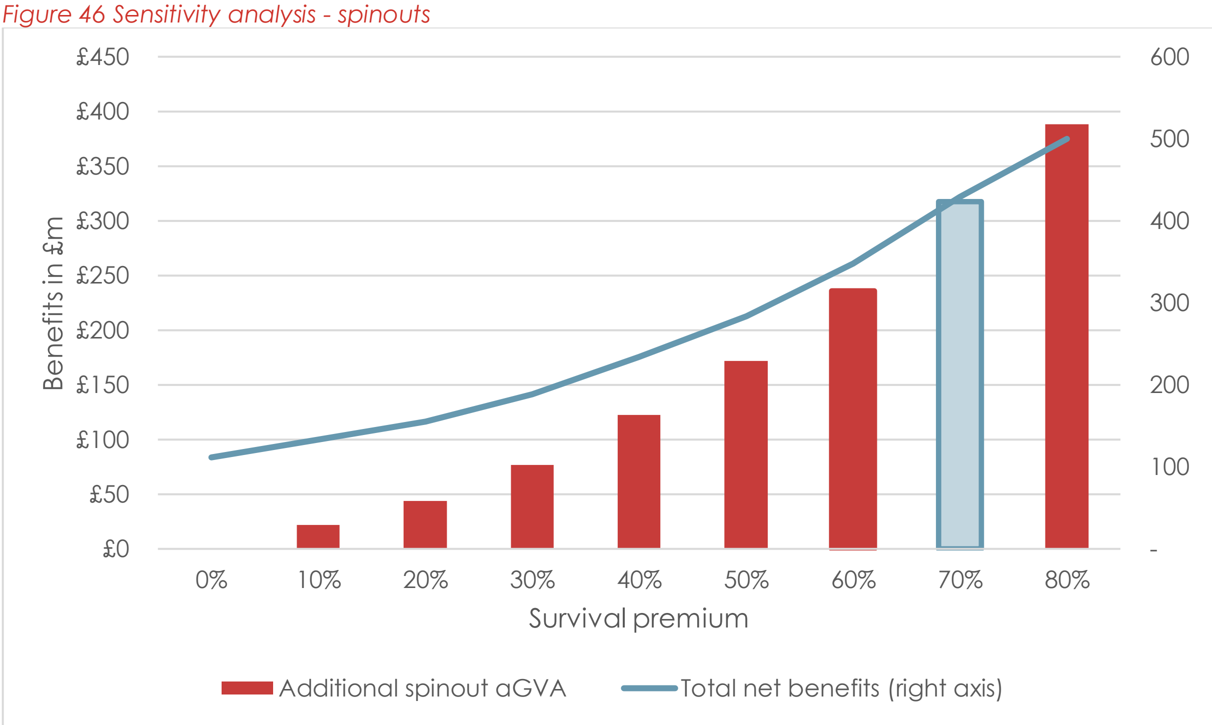


Figure 47 Sensitivity analysis – granted patents

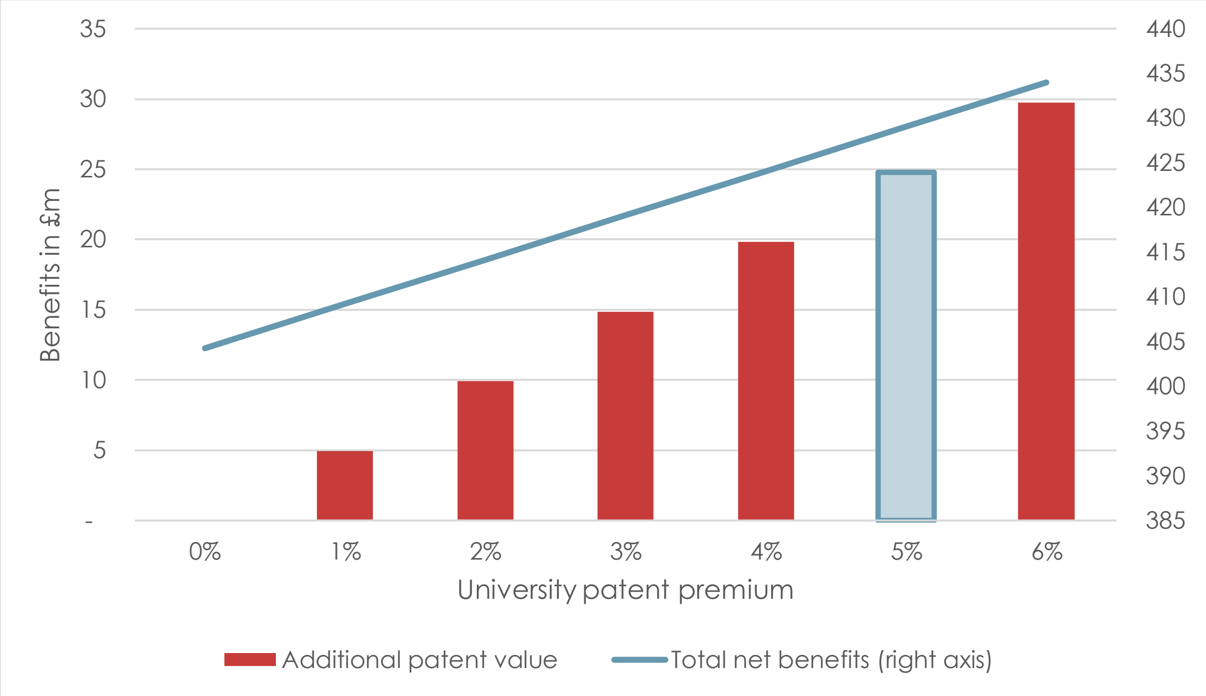


Figure 48 Sensitivity analysis – knowledge spillovers