frontier economics

STATE AID EVALUATION

Final Report

September 2019

Innovate UK

CONTENTS

ACKNOWLEDGEMENT

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EXECUTIVE SUMMARY

Background

Innovate UK (IUK) is part of UK Research and Innovation, a non-departmental body that seeks to drive productivity by supporting businesses to realise the potential of new ideas. IUK oversees a Research, Development and Innovation Scheme. This provides competitive funding for research and development (R&D) in the form of grants and loans. The majority of funding awarded as part of the scheme is included within one of six specific programmes. These programmes operate in different ways and target different groups of beneficiaries:

1. The **Smart programme** is a funding instrument that offers grants to small and medium enterprises (SMEs) across the UK to engage in R&D projects.
2. **Catalysts** are a form of R&D funding that focus on specific priority areas and aim to quickly turn high-quality UK research into commercial projects.
3. The **ICURe programme** aims to tackle barriers which hamper the commercialisation of university research.
4. **Innovation Loans** are aimed at supporting businesses with innovation projects.
5. The **Investment Accelerator Pilot** provides each beneficiary with a package of a public sector grant coupled with private equity investment.
6. **Collaborative R&D** (CR&D) grants are aimed at SMEs and large companies who are seeking to develop new products and services or to use new processes through collaboration with other businesses and academics.

In addition, there are also a small number of residual projects not part of any of the above programmes.[1]

The primary objective of the scheme is to stimulate economic growth through the support of innovative businesses, in particular SMEs, across all sectors of the economy as well as research organisations. The scheme generally supports R&D which is relatively high risk and far from market, although this varies from programme to programme. Individual projects can run for several years and the final impacts of the scheme are likely to take a long time to materialise fully.

IUK's scheme is classified as State aid under European Union (EU) rules because it uses State resources to confer an advantage on a selective basis to chosen recipients and has the potential to distort competition and trade. As the scheme is focused on encouraging R&D, it is covered by the EU's General Block Exemption Regulation. This means that the programmes which make up the scheme do not require prior approval. However, the overall scheme must be evaluated in line with European Commission (EC) rules (EC, 2014 A and 2014 C).

Evaluation question

The focus of this evaluation is on scheme funding from 1 January 2015 to 31 December 2020. In this final evaluation report, we build on an interim report

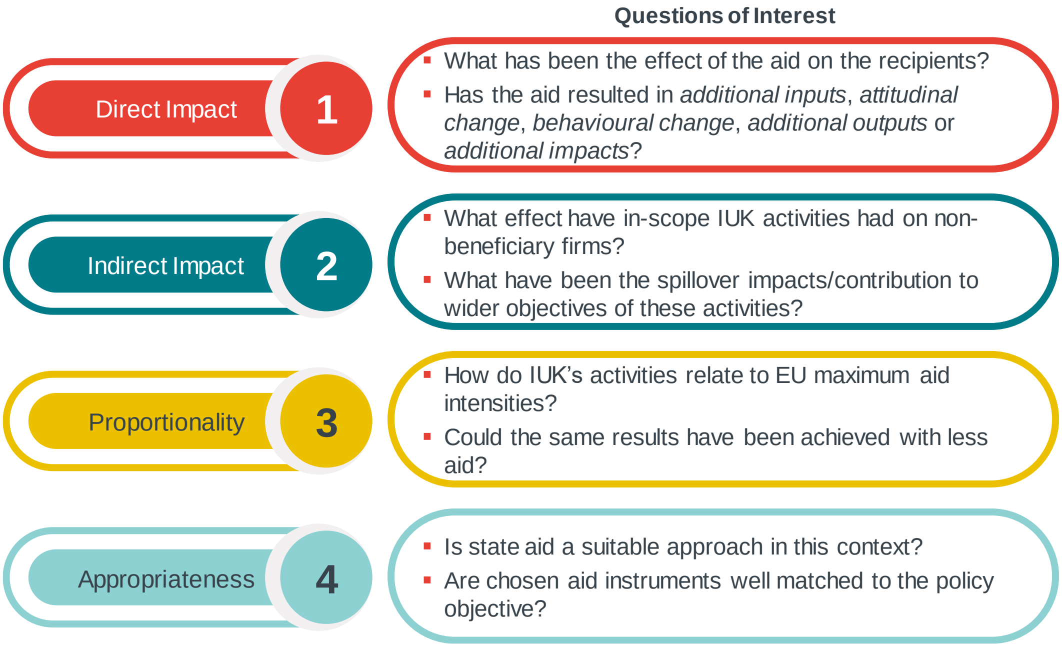
[1] Examples include projects awarded grants through Eurostars competitions and Launchpad competitions.

submitted to the EC in September 2018. In line with EC guidance (2014 A),[2] the objective of our evaluation is to assess the impact of the IUK State aid scheme across four dimensions:

1. Direct impact
2. Indirect impact
3. Proportionality
4. Appropriateness

We present a visual summary of these areas below (Figure 1).

Figure 1 Dimensions of impact



Source: Adapted from EC Common Methodology (EC, 2014 A)

Methodology

As set out in IUK's (2018 A) Evaluation Framework, there are several issues which need to be considered when carrying out evaluation work in the context of R&D. These include the availability of accurate and timely data on measures of interest, the rapid evolution of beneficiary organisations, low observability of key outcomes and the length of time between intervention and emergence of final outcomes.

Our role as the independent single evaluation body is to carry out a single scheme-wide evaluation of the aid which addresses these challenges. As we set out in Figure 2 below, we have used different approaches to address each evaluation question. These methods rely on a combination of ***scheme level*** evidence, which relates to the entirety of the aid scheme, and ***programme level*** evidence, which relates to specific components of the scheme. Where relevant, we have drawn together programme level evidence to come to an overall conclusion on the effectiveness of the scheme.

[2] See p 6-7 http://ec.europa.eu/competition/state_aid/modernisation/state_aid_evaluation_methodology_en.pdf

IUK is fully committed to understanding and improving the effectiveness and efficiency of its activities (IUK, 2018 A). To support this objective, IUK has commissioned a series of evaluations[3] which explore the impact of all specific programmes within the overall aid scheme. These component level evaluations provide robust answers to the core questions set out in the evaluation plan. We have supplemented the programme level evaluations with additional evidence of indirect effects, proportionality and appropriateness to provide a complete evaluation at the scheme level. Drawing on a large number of individual programme level evaluations allows us to maximise the amount of longitudinal evidence currently available. A single more recently commissioned evaluation would be less conclusive in terms of final impacts.

Figure 2 Summary of methodologies used

Dimension	Programme/component level	Scheme level
Direct impact	▪ Econometric comparison of recipient firms and non-recipient firms using survey data ◦ Propensity score matching ◦ Difference-in-difference analysis ◦ Regression discontinuity analysis ▪ Econometric analysis of administrative data to assess business performance of funded firms ▪ Stakeholder engagement and case studies ▪ Analysis of management information	▪ Synthesis of programme level findings to provide overall estimates of scheme impact
Indirect impact	▪ Identification of spillovers via self-report surveys of successful and unsuccessful applicants ▪ Case studies of pairs of beneficiary and non-beneficiary firms	▪ Synthesis of programme level findings ▪ Identification of affected markets via linking of IUK management information to secondary data ▪ Development of hypotheses and selection of appropriate data ◦ Stakeholder engagement ◦ Cross-sectional examination of recipient firms in each market ◦ Time series analysis of competitive dynamics
Proportionality	▪ Exploration of direct impact effect sizes for grants of different sizes ▪ Summary of evidence relating to IUK decision-making process	▪ Analysis of IUK monitoring data to determine aid intensity of each in-scope project

[3] A full list of relevant material is available in Annex A.2.

Dimension	Programme/component level	Scheme level
Appropriateness	▪ Breakdown of IUK funding by scheme component	▪ Assessment of applicability of State aid in the current context ▪ Comparison of UK activities to other EU Member States ▪ Description of IUK portfolio of support mechanisms

Source: Frontier and existing evidence

Note: Further detail on the methods used in existing evaluations is provided in Section 4.2

Direct impact

Direct impacts refer to the effects of the aid on beneficiaries. Direct impacts are likely to occur sequentially. Changes to inputs and attitudes of beneficiaries will be evident in advance of impacts on behaviour, outputs and impacts.

Sophisticated econometric techniques have been used to determine the effects of the scheme on recipients. For example, propensity score matching was employed to balance the characteristics of successful and unsuccessful applicants of a specific programme, and regression discontinuity design was used to compare applicants who had narrowly missed out on funding with those who had received funding but were close to missing out. Overall, the approaches used across the component level evaluations were appropriately robust given the circumstances of the scheme and utilised mixed methods to overcome evaluation challenges in this area.

We have consistent evidence that the aid has made it easier for beneficiary firms to access other forms of finance. In addition, we can conclude, from a number of surveys (of both successful and unsuccessful applicants) and programmes of qualitative research, that the scheme has in several cases led to the development of new skills or increased confidence. The precise magnitude of these effects varies according to the specific programme and recipient group.

Some effects on beneficiary behaviour and outputs are also evident although these findings are less consistent at this stage. For example, we can see that in some cases the IUK aid allowed recipients to progress faster on the commercialisation journey than would have been possible otherwise. Also, certain groups of beneficiary firms experienced statistically significant increases in business outcomes, such as employment and turnover, as a result of the aid. However, these effects were not yet evident across all programmes.

Indirect impact

Indirect impacts refer to the effects of the IUK scheme on non-beneficiary firms or the wider economy. These indirect effects can be positive if the aid scheme leads to beneficial spillover effects on other firms via the dissemination of knowledge or the establishment of new supplier or customer relationships. State aid can also lead to negative indirect effects if for example the supported innovation is not replicable by competitors. This could in turn result in a distortion of competition within or between Member States. However, the existence of a negative indirect effect does not necessarily lead to a distortion in competition as the aid may be addressing a market failure.

We know from the component level evaluations that beneficiary firms felt the aid scheme also benefitted non-recipients such as suppliers and customers. Identified benefits include access to new markets or increased knowledge. Negative spillovers were less commonly identified. Engagement with indirect beneficiaries revealed that in some cases they experienced the spillovers identified by direct beneficiaries. However, in other case studies, the indirect beneficiary had not experienced the spillovers that the direct beneficiary had reported. The body of existing evidence strongly suggests that there may be indirect benefits, but the evidence is not yet conclusive.

To explore the possibility of the scheme resulting in negative indirect effects we carried out an evaluation of the potential trade and competition effects of the aid using a methodology which is based on published EC guidelines (EC, 2014 A) and an EC report on Ex Post Assessment of the Impact of State Aid on Competition (Oxera, 2017).

We used a mixed-methods approach to conclude that the IUK aid ***does not*** pose material competition concerns in the four representative markets we selected. This is because:

- The aid generally funds projects which are high risk and are not close to market. This means that the commercial impact of any supported project is uncertain. Even if a supported project does lead to commercial outcomes these typically take several years to materialise. As per EC guidance (2014 C),[4] this minimises the potential negative incentive effects on other market participants and significantly reduces the likelihood of crowding out.
- The aid awarded by IUK constitutes a very small proportion of all R&D carried out across the four markets we considered. Market participants typically fund R&D using alternative mechanisms. In addition, IUK aid is contingent on the recipient firm providing match funding. In general, the supported projects take several years and constitute only a part of the journey from fundamental research to commercialisation. Therefore, the IUK aid by itself will not be sufficient to support an entire project but instead helps to overcome specific barriers or bottlenecks which are limiting the amount of R&D being carried out.
- IUK aid is awarded based on a rigorous and proportionate review process, informed by independent sectoral expertise. This ensures that IUK is funding firms who are best placed to carry out innovative R&D projects and also helps to focus the aid on neglected areas of research where public intervention is most acutely needed. The aid does not pre-select beneficiary firms prior to the submission of applications, which would increase the chance of distortions arising.
- Our analysis indicated that a firm's decision to locate in a specific Member Sate will be driven by a range of factors including closeness to customers and availability of skilled employees. IUK aid is highly unlikely to be the deciding factor in terms of the location in which a firm carries out its R&D. This is because

[4] See p 24, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XC0627(01)&from=EN

firms would need to locate in the UK before applying for the aid, which they would not be certain of receiving.

- It is highly implausible that a recipient firm could materially strengthen or achieve a dominant position which would cause harm to consumers as a direct result of receiving IUK aid. There is no evidence that this has occurred to date. The affected markets that we examined in depth are all expected to grow significantly in the coming years, which means that multiple firms can be accommodated without exit. In addition, the ultimate impact of each IUK grant/loan is highly uncertain, which helps to minimise crowding out. Finally, the markets affected are themselves generally competitive and unlikely to be characterised by a 'winner-takes-all' structure.

Proportionality

The scheme operates within EC guidelines on maximum aid intensities to ensure proportionality of funds awarded (EC, 2014 C).[5] Amongst private sector firms, most grants cover around half of a recipient firm's R&D costs for a specific project. Specifically, amongst private sector firms, 96% of grants cover between 41% and 70% of a firm's costs.

Furthermore, larger applications to certain programmes are less likely to be funded by IUK than smaller applications. IUK feedback has led to a reduction in stated project costs for many projects and projects below the maximum grant level are often funded. Together, this suggests that each application is proportionally funded based on need rather than administrative thresholds.

Appropriateness

The most appropriate form of State aid will be the aid instruments which achieve the overall objectives with the fewest distortions to competition and trade.

The use of State aid in this context is appropriate due to the existence of market failures which surround investment in R&D. The EC (2014 B)[6] highlights externalities as a cause of this market failure, as actors other than the innovator can benefit from R&D activity. In addition, R&D projects might suffer from insufficient access to finance (due to asymmetric information) or from coordination problems amongst firms (EC, 2014 B).[7] State aid to promote R&D is generally viewed by the EC as 'good aid' (Belmin and Zenger, 2016). This is in keeping with the EC's own objective to increase R&D as a proportion of GDP to 3%.

The wide variety of different support options and delivery mechanisms included in the scheme ensures that aid is suitably tailored to tackle specific challenges. The majority of IUK aid is awarded in the form of grants. Grants are an appropriate instrument as the projects funded are generally far away from the market and commercial success is highly uncertain and will not materialise soon. More recently, following engagement with businesses, IUK has introduced Innovation

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[5] See p 29, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XC0627(01)&from=EN

[6] See for example p 9, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0651&from=EN

[7] See for example p 8, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0651&from=EN

Loans. This type of support aims to encourage later-stage R&D with a clearer route to commercial success.

As noted in the evaluation plan it may be that one type of support mechanism within the portfolio consistently leads to larger direct impacts than other programmes, or is less likely to distort trade or competition. However, currently it is not possible for us to make this comparison in a robust manner as the individual programmes which make up the scheme are at different stages of the evaluation cycle.

In the future it may be possible to compare the effectiveness of the IUK scheme to equivalent programmes implemented by other Member States. This sort of comparison is unlikely to be conclusive as the relevant contexts which apply to each scheme will differ markedly and equivalent evidence may not always be available on a consistent basis.

1 INTRODUCTION AND BACKGROUND

1.1 Terms of reference

UK Research and Innovation (UKRI) commissioned Frontier Economics[8] to carry out an independent assessment of the overall effect of Innovate UK's (IUK) Research, Development and Innovation Scheme, which is covered by European Union State Aid rules.

This final evaluation report provides our assessment of the extent to which the scheme drives innovation while taking into consideration any negative competition and trade impacts. The funding period covered by this evaluation is 1 January 2015 to 31 December 2020. Therefore, given the timing of this final report, some of the most recent aid awarded will not feature in our evaluation.

Our evaluation assesses the impact of the IUK State aid scheme across four dimensions:

1. Direct impact
2. Indirect impact
3. Proportionality
4. Appropriateness

The evidence reported is drawn from:

- independent evaluations of each of the programmes; and
- assessment of indirect effects, proportionality and appropriateness carried out at the scheme level.

This report builds on an interim report submitted to the European Commission (EC) in September 2018. The interim report contained a preliminary synthesis of programme level direct impacts and set out how we planned to assess indirect other dimensions at the scheme level. The evidence synthesis is now complete, and we have carried out the scheme level analysis. All the findings and views expressed in this report are based on Frontier Economics' independent assessment and do not necessarily reflect those of the Department for Business, Energy and Industrial Strategy (BEIS) or IUK.

1.2 Context of this report

1.2.1 Innovate UK is the UK's innovation agency

IUK is part of UK Research and Innovation, a non-departmental public body funded by a grant-in-aid from the UK government.[9] IUK was previously known as the

8 Frontier Economics is an independent microeconomic consultancy with offices in Berlin, Brussels, Cologne, Dublin, Madrid, London and Paris. We work with policy makers and business across Europe, in all major public sectors and areas of public policy. We help them understand what policy solutions might look like and whether they have been effective, by offering appraisal, evaluation, experimentation, modelling and strategy advice. We pride ourselves on the rigour and the independence of our work.

9 Further information is available on UKRI's website: https://www.ukri.org/

Technology Strategy Board, which was established in 2007 (IUK, 2017 C).[10] Domestically, IUK operates under the Science and Technology Act 1965.[11]

IUK seeks to drive productivity and economic growth by supporting businesses to develop and realise the potential of new ideas.[12] Specifically, IUK works with people, companies and partner organisations to find and drive the science and technology innovations that will grow the UK economy.

IUK activity aligns with the recent BEIS Industrial Strategy (BEIS, 2017) by helping to achieve the ambition of making the UK the world's most innovative economy. Over the last 12 years, IUK have invested over £2.2 billion in innovation. IUK's Delivery Plan for 2019 (IUK, 2019) sets out the agency's mission to drive sustainable economic growth through business-led innovation.[13]

1.3 Background and scope of our evaluation

1.3.1 State aid in the European Union

What is State aid?

The EC defines State aid as an intervention that meets the following four criteria:

1. The intervention must be by the state or use state resources.
2. The intervention must give the recipient an advantage on a selective basis.
3. Competition has been or may be distorted.
4. The intervention is likely to affect trade between Member States.[14]

Why control State aid?

Article 107[15] of the Treaty on the Functioning of the European Union (TFEU) contains a general prohibition of State aid to ensure that aid does not distort competition and trade within the EU by favouring certain companies or the production of certain goods (BIS, 2011).

However, in some circumstances, aid is necessary for a well-functioning economy to offset market failure. This is reflected in Commission Regulation (EU) No 651/2014, which declares certain types of aid for innovation compatible with the common market in application of Articles 107 and 108 of the TFEU (EC, 2014 D).[16]

The EC is responsible for enforcing the EU State aid rules.[17]

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10 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/645036/10th_Anniversary_Brochure_WEB.pdf

11 http://www.legislation.gov.uk/ukpga/1965/4/contents

12 https://www.gov.uk/government/organisations/innovate-uk/about

13 https://www.ukri.org/files/about/dps/innovate-uk-dp-2019/

14 http://ec.europa.eu/competition/state_aid/overview/index_en.html

15 https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:12008E107&from=EN

16 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2014.187.01.0001.01.ENG

17 http://ec.europa.eu/competition/state_aid/overview/state_aid_procedures_en.html

Notified aid

In general, EU State aid rules require Member States to notify the EC of new aid measures and Member States must wait for the EC's decision before they can put the aid measure into effect. However, there are a few exceptions to mandatory notification, for example:

- de minimis aid not exceeding €200,000 per undertaking over any period of three fiscal years (€100,000 in the road transport sector);
- aid granted under an aid scheme already authorised by the EC; or
- aid covered by a block exemption (giving automatic approval for a range of aid measures defined by the EC).

1.3.2 Block exemption

The General Block Exemption Regulation (GBER) outlines a range of State aid types that, provided certain conditions are met, do not require individual approval (EC, 2014 D). The EC identified a series of research and development and innovation (R&D&I) measures which may be compatible with the internal market under certain conditions. These include: [18]

- aid for research and development (R&D) projects; [19]
- aid for feasibility studies; [20]
- aid for the construction and upgrade of research infrastructures; [21]
- aid for innovation activities; [22] and
- aid for innovation clusters. [23]

This block exemption is justified on the basis that promoting R&D&I is an important EU objective and that the Europe 2020[24] strategy identifies R&D as a key driver for achieving the objectives of smart, sustainable and inclusive growth (EC, 2010). Also, the EU has acknowledged that many aid measures for innovation are relatively small and create no significant distortions of competition (EC, 2013).[25]

1.3.3 Need for evaluation

Under Article 1(2)(a) of the GBER, aid schemes whose 'average annual State aid budget exceeds EUR 150million' are exempted from the notification obligation only for a period of six months after their entry into force. This exemption can be prolonged for a longer period authorised by the EC following the assessment of an evaluation plan notified by the Member State concerned (EC, 2014 B).[26]

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18 The GBER was revised in 2014 to include additional categories of aid. See http://europa.eu/rapid/press-release_MEMO-14-369_en.htm for further details.

19 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0651&from=EN, see p 8

20 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0651&from=EN, see p 8

21 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0651&from=EN, see p 48

22 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0651&from=EN, see p 50

23 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0651&from=EN, see p 49

24 https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex:52010DC2020

25 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2013.204.01.0011.01.ENG

26 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0651&from=EN, see p 16

The EC has set out a Common Methodology for State Aid Evaluation (EC, 2014 A).[27] This document emphasises the importance of ex post evaluation of aid schemes as they allow decision makers both at the Member State and EU level to consider the measurable results of State aid granted in the past, and the lessons learnt. As such, evaluations can help to ensure that future schemes financed by State aid are more effective and create less distortion.

The IUK aid scheme was put into effect on 1 January 2015 and has an annual budget of £600 million, thus constituting a large scheme within the meaning of Article 1(2)(a) of the GBER.

The UK notified the EC of an evaluation plan for the aid scheme on 30 January 2015. Having assessed the evaluation plan, the EC decided that Commission Regulation (EU) No 651/2014 would continue to apply to the IUK (Technology Strategy Board) Research, Development and Innovation Scheme 2014 until 31 December 2020 and therefore individual interventions within the aid scheme would not require approval from the EC before being administered.

The evaluation plan agreed by the EC and IUK is being implemented as part of this work (EC, 2015 A). This involves the use of robust evaluation techniques to create evidence and insight for the State aid modernisation initiative. In addition, the evaluation will help IUK to better understand what works and improve the design and delivery of its programmes going forward (IUK, 2018 A).[28]

1.3.4 Report structure

This final evaluation report provides a holistic evaluation of IUK's aid scheme in line with the EC's guidelines. The remainder of the report is set out as follows:

- In Chapter 2 we describe the aid scheme in terms of the amount of funding awarded over time, the component programmes and the recipients.
- In Chapter 3 we outline the methodologies that we used to address each .area of interest;
- In Chapter 4 we present our findings relating to the direct impact of the scheme.
- In Chapter 5 we present our findings relating to the programme level indirect impacts of the scheme.
- In Chapters 6 and 7 we identify markets which could have been adversely affected by the scheme and develop hypotheses which we can test to determine whether any distortions to trade and competition have occurred.
- In Chapters 8, 9 and 10 we present the results of the hypotheses testing across the markets of interest.
- In Chapters 11 and 12 we set out our findings relating to the proportionality and appropriateness of the scheme respectively.

[27] http://ec.europa.eu/competition/state_aid/modernisation/state_aid_evaluation_methodology_en.pdf

[28] https://www.gov.uk/government/publications/evaluation-framework

2 DESCRIPTION OF AID SCHEME

2.1 The Innovate UK aid scheme

Certain R&D&I measures administered by Innovate UK (IUK) fall under European Commission (EC) State Aid regulation. Formally these R&D&I measures are collectively known as the Innovate UK (Technology Strategy Board) Research, Development and Innovation Scheme 2014, which we refer to as 'the aid scheme'.

Objectives of the aid scheme

The primary objective of the aid scheme is to stimulate economic growth through the support of innovative businesses, in particular small and medium enterprises (SMEs), across all sectors of the economy as well as research organisations.

The aid scheme also has secondary objectives, which include increasing knowledge transfer and creation, the development of innovation skills and the production of new goods and services. The scheme also seeks to incentivise cooperation and collaboration between companies and research organisations, including higher education institutions.

Components of the aid scheme

The aid scheme has an annual budget of £600 million. Funding is provided in the form of grants, loans and repayable advances within the maximum aid intensities set out in the EC's Framework for State Aid for Research and Development and Innovation (EC, 2014 C).[29] Beneficiaries of the aid scheme include private sector organisations of all sizes, as well as other non-private sector organisations including research organisations, public sector organisations and charities. Certain programmes within the aid scheme are targeted at specific groups of enterprises, such as SMEs (EC, 2015 A).[30]

The aid scheme covers the following aid measures:

- aid for consultancy in favour of SMEs (Article 18 of the General Block Exemption Regulation (GBER));
- aid to SMEs for participation in fairs (Article 19 of the GBER);
- aid for start-ups (Article 22 of the GBER);
- aid for scouting costs (Article 24 of the GBER);
- aid for R&D projects (Article 25 of the GBER);
- investment aid for research infrastructures (Article 26 of the GBER);
- aid for innovation clusters (Article 27 of the GBER);
- innovation aid for SMEs (Article 28 of the GBER);
- aid for process and organisational innovation (Article 29 of the GBER); and
- aid for R&D in the fishery and aquaculture sector (Article 30 of the GBER).

[29] See p 29, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XC0627(01)&from=EN

[30] See p 2, http://ec.europa.eu/competition/state_aid/cases/256732/256732_1703219_80_2.pdf

The majority of funding awarded as part of the scheme is included within one of six specific programmes. These programmes operate in different ways and target different groups of beneficiaries:[31]

1. The **Smart programme** is a funding instrument that offers grants to SMEs across the UK to engage in R&D projects. IUK took on responsibility for Smart in 2011. Smart operates in parallel with IUK's sector- and technology-based innovation support and other activities which target different stages of the innovation journey. Three grant types are available through Smart: Proof of Market, Proof of Concept and Development of Prototype (SQW, 2015). The Smart programme has been superseded by IUK's Open R&D Funding programme which also provides business with grants to develop innovative ideas. Specifically, the Open programme will support projects which develop a completely new product, service or process, or work that involves an unprecedented use for an existing one. As with the Smart programme, it supports innovation at various stages.[32]
2. **Catalysts** are a form of R&D funding that focus on specific priority areas and aim to quickly turn high-quality UK research into commercial projects. There are three main phases of funding: Feasibility Studies, Industrial Research and Experimental Development (IUK, 2014).
3. The **ICURe programme** aims to tackle barriers which hamper the commercialisation of university research. The pilot was established following evidence that more should be done to create a commercial demand for university engagement. Grant funding is provided to fund salary and travel costs of participating academic teams (Ipsos MORI, 2018 B).
4. **Innovation Loans** are aimed at supporting businesses with innovation projects that are near to market. IUK is running a pilot programme of loan competitions over two years to the end of 2019. Through the pilot, innovation loans are offered to SMEs that want to scale up and grow by developing new or improved products, processes or services. Loans are offered at below-market rates of interest. The value of this differential between the rate offered and the commercial rate over the life of the loan will be the equivalent of a grant and constitutes a form of State aid (IUK, 2017 B).[33]
5. The **Investment Accelerator Pilot** (IAP) provides each beneficiary with a package of a public sector grant coupled together with private equity investment. The scheme was launched by IUK in 2017 with a single competition, on a pilot programme, and aimed at firms in the early-stage R&D process. The IAP concept was founded on evidence that businesses who secure both grants and equity tend to raise more money and achieve high value valuations than either alone. In order to secure finance, an applicant had to demonstrate a novel and innovative idea and market growth potential. The IAP programme was open to firms from the life sciences or infrastructure sectors (SQW, 2019 A).

[31] https://www.gov.uk/guidance/innovate-uk-funding-general-guidance-for-applicants

[32] https://www.gov.uk/government/collections/innovate-uk-open-funding-programme

[33] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/676579/17.3215.185_Loans_Brochure_RatherNiceDesign_FINAL_Web.pdf

6. **Collaborative R&D** (CR&D) grants are aimed at SMEs and large companies who are seeking to develop new products and services or use new processes through collaboration with other businesses and academics. CR&D grants aim to promote collaboration and knowledge-sharing between businesses and other partners (IUK, 2014). The CR&D programme covers industrial research, feasibility studies and experimental research.

All the funding mechanisms we list above operate on the basis of a competitive application process. Individual projects are evaluated by a panel of independent assessors who consider their technical feasibility, the risks involved, the viability of the commercialisation and exploitation plans, and the necessity for government support (EC, 2015 A).[34] In addition, there are also a small number of residual projects not part of any of the above programmes. Examples include projects awarded grants through Eurostars[35] competitions and Launchpad[36] competitions. These residual projects account for 12% of IUK funding subject to State aid rules and distributed between 2014/15 and 2017/18.

2.2 Analysis of aid

In the remainder of this chapter, we describe the aid scheme. This sets out how the aid works, provides context for the causal effects identified in later chapters and provides the basis for hypotheses about how the aid may have affected competition and trade.

Our description of the aid scheme is based on an analysis of IUK monitoring data.[37] This data was referred to in the evaluation plan (EC, 2015 A).[38] The data is based on a mixture of IUK records and company self-reporting via funding application forms. The data includes detailed information on all projects funded by IUK. Variables include, for each recipient on each project:

- the **project name**;
- the **programme(s)** the project falls under;[39]
- the **aid intensity**, measured as the proportion of recipient costs covered by the grant;
- the **organisation type** of the recipient, e.g. large company, SME, public sector organisation;
- the **location** of the recipient;
- the **Company Registration Number** of the recipient (if appropriate);
- the amount of **funding committed** by IUK;[40] and
- the amount of **funding received** by the recipient, by financial year.

[34] http://ec.europa.eu/competition/state_aid/cases/256732/256732_1703219_80_2.pdf

[35] https://www.eurostars-eureka.eu/about-eurostars

[36] https://www.gov.uk/government/collections/launchpad-directories

[37] A similar non-confidential dataset listing IUK projects is available online, see https://www.gov.uk/government/publications/innovate-uk-funded-projects. Data on IUK projects is also available on the UK Research and Innovation website: https://gtr.ukri.org/.

[38] See p 4, http://ec.europa.eu/competition/state_aid/cases/256732/256732_1703219_80_2.pdf

[39] Some projects fall under multiple programmes.

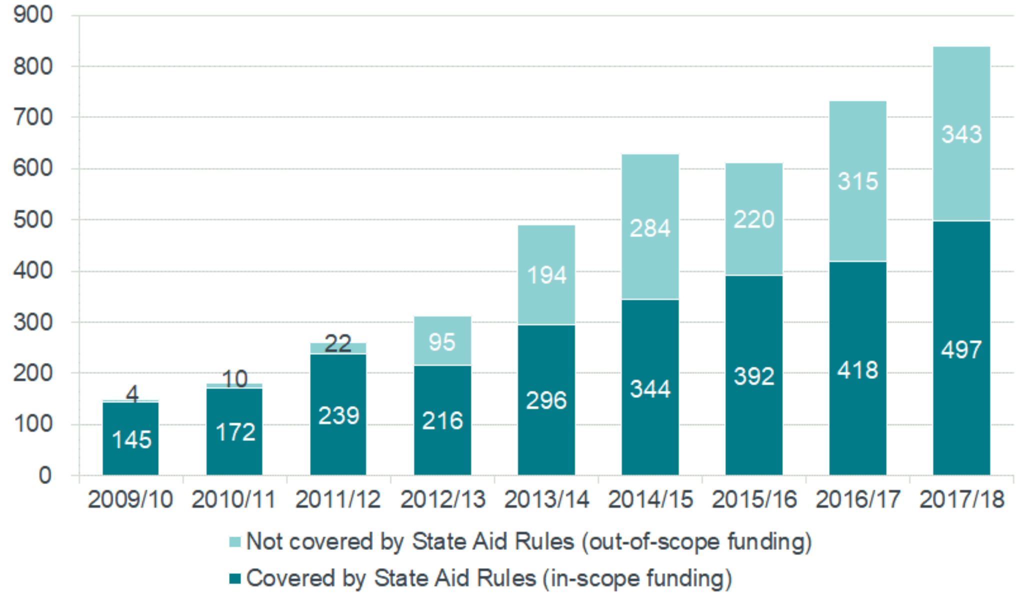
[40] Funding committed refers to the total amount of funding that IUK agreed to provide to an organisation for a given project and this funding is usually distributed over a number of years.

2.2.1 In-scope and out-of-scope aid

Figure 3 shows that the total overall amount of funding distributed by IUK increased from £149m in 2009/10 to £840m in 2017/18.[41] [42] These totals refer to funding actually distributed by IUK to recipients (rather than funding committed by IUK at the start of a project).

The majority of this funding, 59% over the most recent four years of data, is covered by EC State aid rules. The remaining 41% of the funding distributed by IUK is not covered by State Aid rules.[43] Both types of funding have increased steadily over time.

Figure 3 Aid status of net funding distributed by Innovate UK 2009-10 to 2017-18 (£ millions)



Source: Frontier analysis of IUK data

Note: (1) Based on actual funding distributed rather than funding committed. (2) Funding measured on net basis (i.e. includes refunds to IUK).

As shown in Figure 4, aid that falls under EC state aid rules can be further divided into funding that relates to the current aid scheme (i.e. funding for projects starting after January 2015) and funding that relates to previous IUK aid schemes (i.e. funding for projects starting before January 2015).

Funding under previous aid schemes peaked at £343 million in 2014/15. Since January 2015 no new projects have started under previous schemes so although funding continues to be distributed as part of legacy projects. In contrast, the current aid scheme began by distributing £108 million in 2015/16 and funding

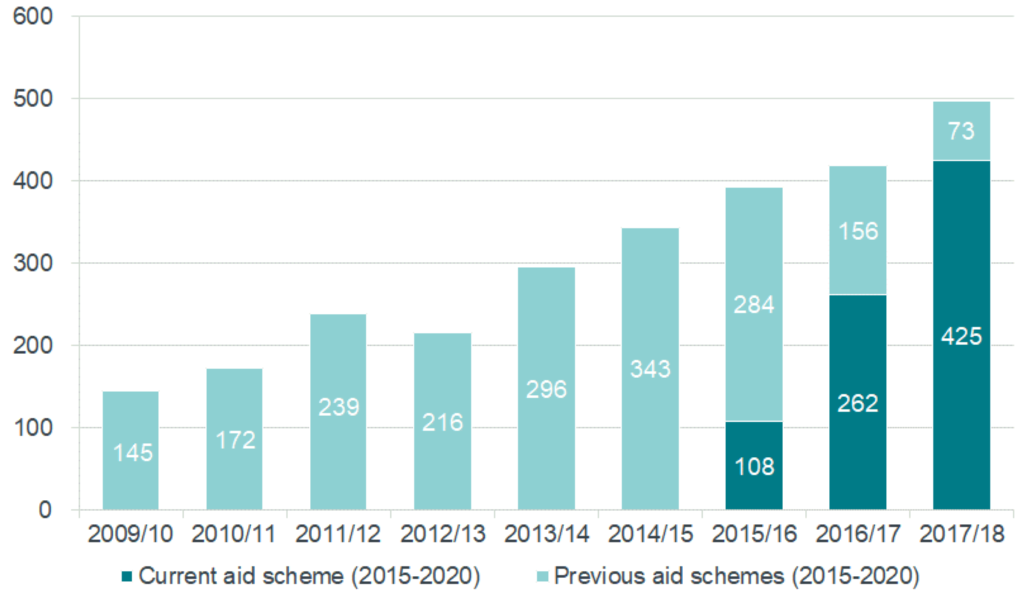
41 Funding is measured on a net basis in the sense that it includes refunds to IUK.

42 For consistency with the firm-level microdata used later in this evaluation, the analysis here focuses on financial year (April to March) rather than calendar year (January to December). We understand that this approach may not align with IUK's usual data reporting practices and therefore one would expect some differences to IUK's own published statistics.

43 E.g. Funding distributed by Innovate UK through its Catapults Network, Small Business Research Initiative, Knowledge Transfer Network, Knowledge Transfer Partnerships and Innovation Vouchers. This also includes de minimis funding.

distributed has since ramped up to £262 million in 2016/17 and £425 million in 2017/18.[44]

Figure 4 Net funding distributed by Innovate UK 2009-10 to 2017-18 by current and previous aid schemes (£ millions)



Source: *Frontier analysis of IUK data*

Note: *(1) Based on actual funding distributed rather than funding committed. (2) Funding measured on net basis (i.e. includes refunds to IUK).*

Our assessment of indirect effects includes aid distributed under both the current aid scheme and older aid schemes. This is because:

- Funding awarded under older IUK aid schemes has continued to been distributed in our evaluation period.
- Current aid scheme funding is mostly similar to funding under older aid schemes. For example, the CR&D programme has operated under both current and older schemes.
- Incorporating funding awarded under previous schemes provides a more comprehensive and holistic evaluation of the competition and trade impacts of IUK funding.

To provide context for our assessment of indirect effects, the rest of this chapter provides summary statistics on all aid falling under EC rules, even if it was awarded as part of a previous IUK aid scheme. We refer to all funding that falls under EC State aid rules as in-scope funding and refer to funding that does not fall under EC State Aid rules as out-of-scope funding.

As shown in Figure 5, the beneficiaries of in-scope funding include not only private sector organisations but also other types of organisation such as universities and Research and Technology Organisations.[45] The individual programme level evaluations consider the impact of the aid on all beneficiaries. However, our

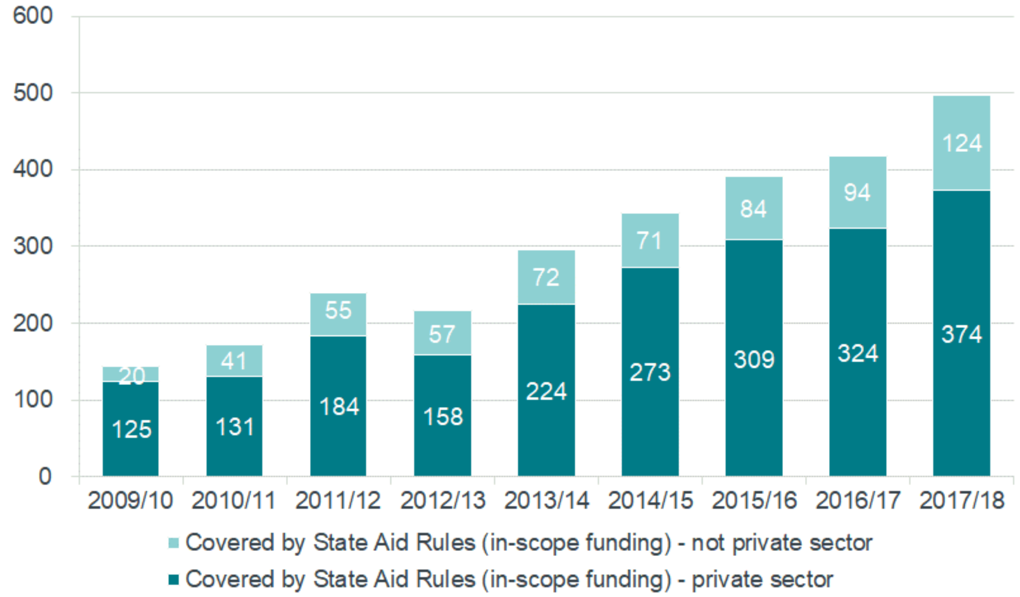
44 We note that this differs from the £600m per year specified in the Evaluation Plan. This is because the £600m per year figure was only a forecast for the financial budget of the aid scheme. In practice, total aid distributed, at least in the early years of the scheme, has been less than originally forecasted.

45 https://s3platform.jrc.ec.europa.eu/rtos

assessment of indirect effects focuses on aid to private sector organisations only. This is because we believe that aid to private sector organisations is more likely to impact competition and trade and is more directly linked to an economic market.[46] Nevertheless, for context, in this chapter we also provide a high level description of the aid received by non-private sector organisations.

Focusing on aid covered by State aid rules over the four years most closely corresponding to our evaluation period, 2014/15 to 2017/18, in-scope aid has averaged £413m per year with £320m per year (77%) going to private sector organisations and £93m per year (23%) going to organisations outside the private sector.

Figure 5 Net funding distributed by Innovate UK 2009-10 to 2017-18 under State aid rules and by organisation type (£ millions)



Source: Frontier analysis of IUK data

Note: (1) Based on actual funding distributed rather than funding committed. (2) Funding measured on net basis (i.e. includes refunds to IUK). (3) Private sector categorisation based on company self-reports.

2.2.2 Analysis of in-scope funding

Grants and projects

Figure 6 shows the number of grants and projects between 2014/15 and 2017/18 for each in-scope programme.[47] Overall, there were 12,562 grants across 6,270 projects, an average of 2.0 grants per project.

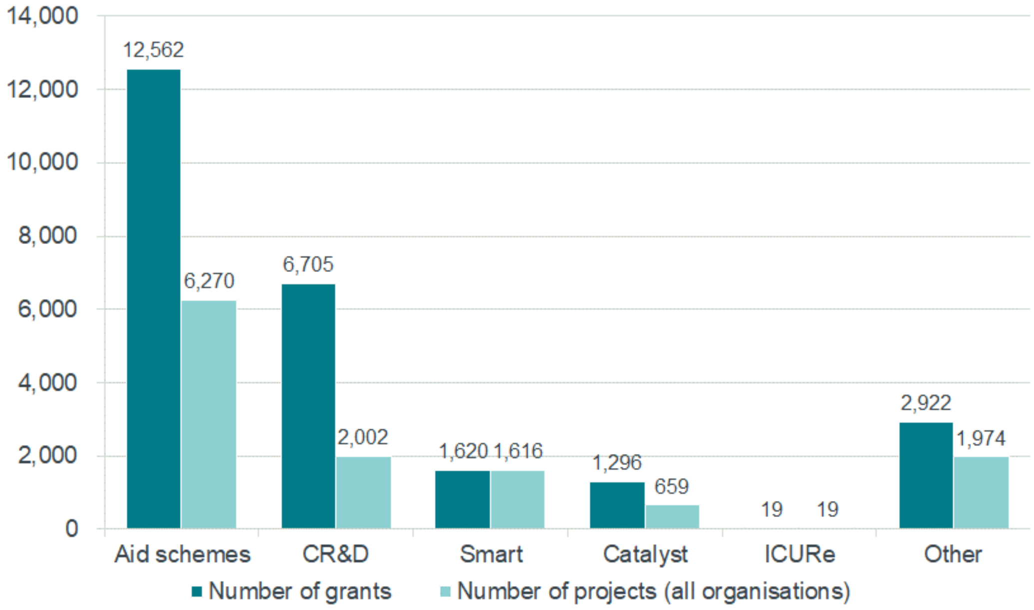
CR&D is the largest programme accounting for more than half of grants (53%), followed by Smart (13%), Catalyst (10%), ICURe (0.2%) and Other (23%). Innovation Loans and the Investment Accelerator Pilot do not appear in Figure 6 because these are new programmes that first distributed funding in 2018/19.

[46] See Chapter 6 for more information on the difficultly of determining the economic market impacted by aid to research organisations, public sector organisations and charities.

[47] Grants / projects are only included if a positive amount funding was distributed between 2014/15 and 2017/18.

The programmes differ in the average number of grants awarded per project. Smart and ICURe fund one grant per project whereas the Catalyst programme (2.0 grants per project) and, unsurprisingly, the CR&D programme which explicitly focuses on promoting collaboration (3.3 grants per project) fund multiple grants per project. As such the CR&D programme accounts for a larger proportion of grants (53%) than projects (32%).

Figure 6 Number of grants and projects by programme (2014/15 to 2017/18)

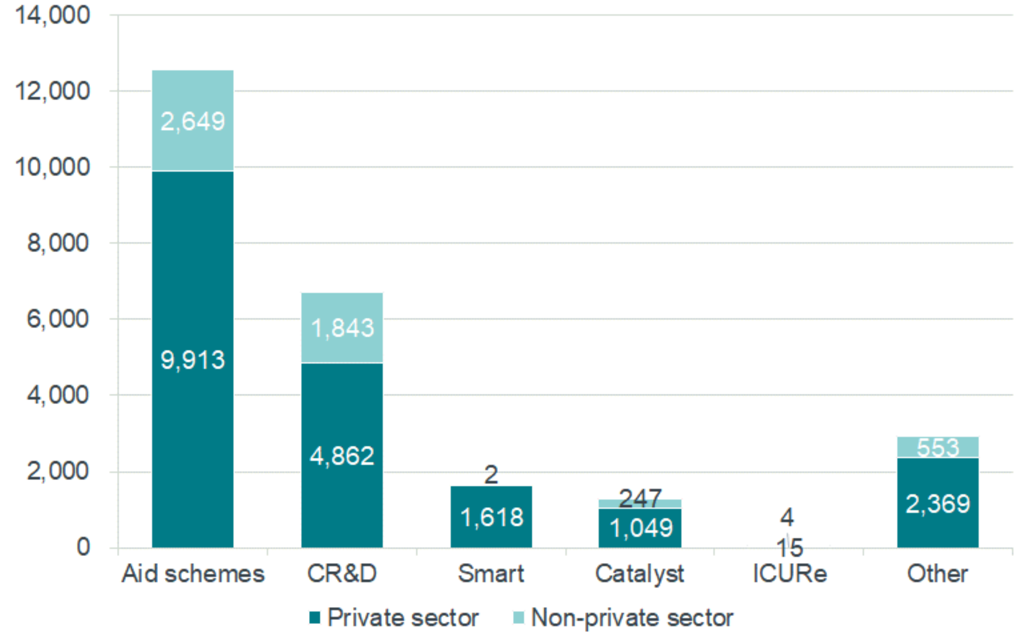


Source: Frontier analysis of Innovate UK data

Note: (1) Sample includes organisations that received in-scope IUK funding between 2014/15 and 2017/18. (2) A single recipient organisation can receive multiple grants if it received funding for multiple different projects. (3) Includes both private and non-private sector firms.

In Figure 7 we present the split of in-scope grants between private sector and other types of organisation between 2014/15 and 2017/18. Overall 79% of grants go to private sector organisations but with some variation across programmes. For instance in the Smart programme, 100% of grants go to private sector organisations while 73% do in the CR&D programme.

Figure 7 Number of grants by organisation type and programme (2014/15 to 2017/18)

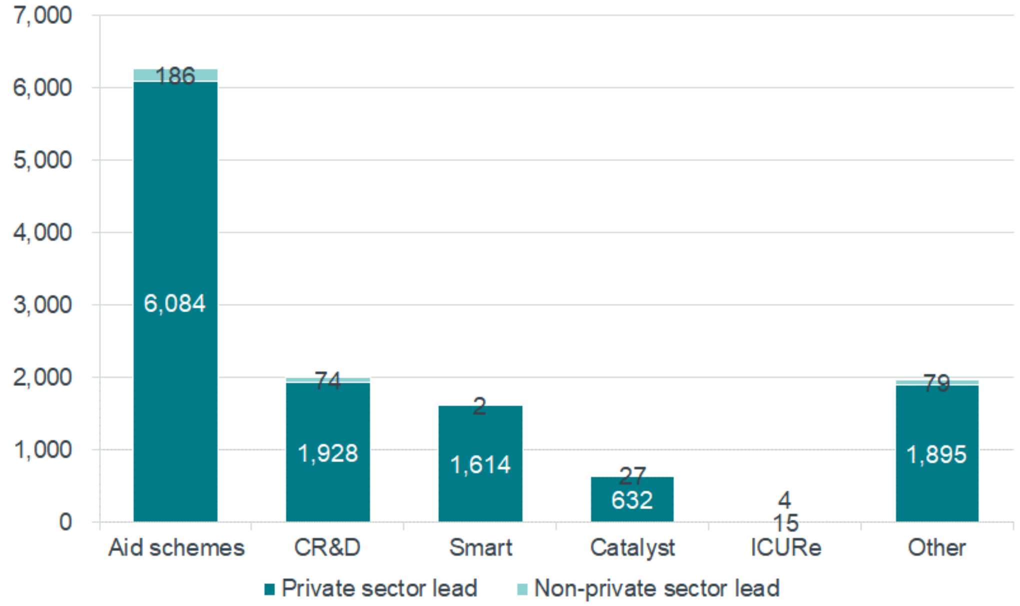


Source: Frontier analysis of Innovate UK data

Note: (1) Sample includes organisations that received in-scope IUK funding between 2014/15 and 2017/18. (2) A single recipient organisation can receive multiple grants if it received funding for multiple different projects. (3) Private sector categorisation based on company self-reports.

In the majority of cases, projects are led by private sector organisations; other types of organisations tend to be collaborators. Specifically, as illustrated by Figure 8, the majority (97%) of in-scope projects between 2014/15 and 2017/18 had a private sector lead.

Figure 8 Project leads by organisation type and programme (2014/15 to 2017/18)



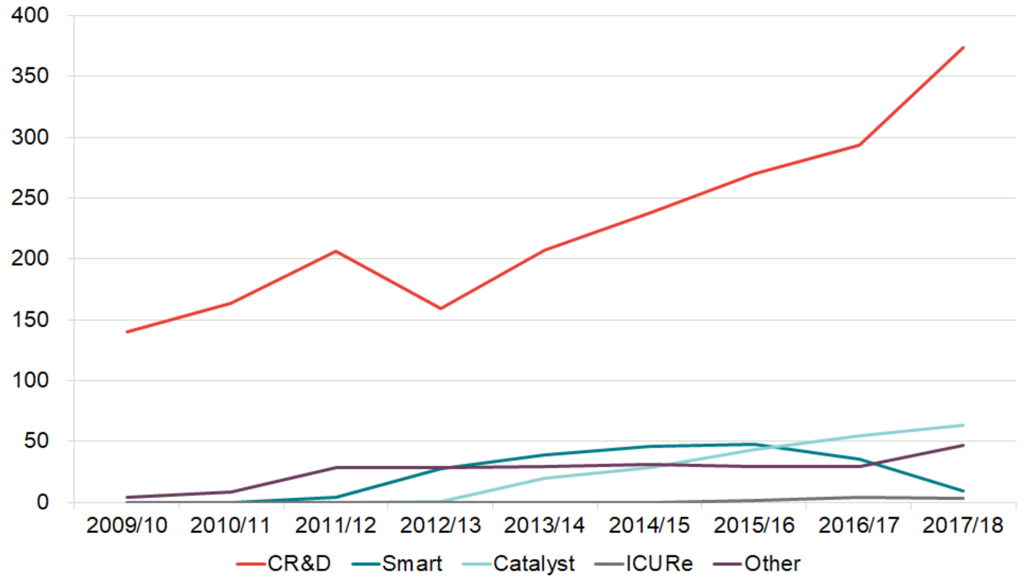
Source: Frontier analysis of Innovate UK data

Note: *(1) Sample includes organisations that received in-scope IUK funding between 2014/15 and 2017/18. (2) A single recipient organisation can receive multiple grants if it received funding for multiple different projects. (3) Private sector categorisation based on company self-reports.*

Funding

As we note above, total funding distributed across in-scope programmes has increased steadily over time. In Figure 9 above we illustrate that the increase has been driven largely by increases in CR&D funding.[48] Catalyst funding has also increased relatively linearly over time while Smart funding peaked in 2015/16 and has declined since.[49] Our analysis (Figure 10) shows the same trends are evident when we focus exclusively on funding distributed to private sector organisations.

Figure 9 Total net funding distributed to all organisations (£ million) by programme and year



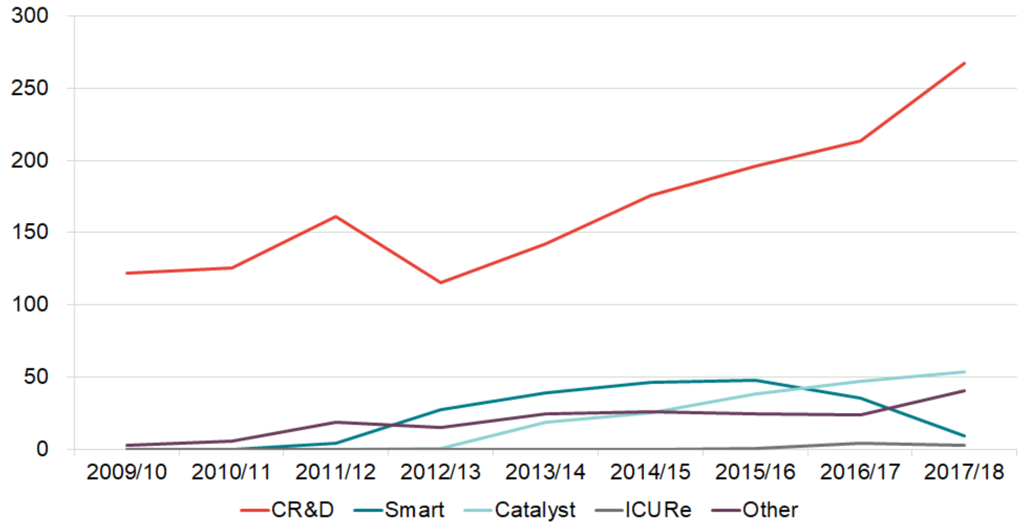
Source: *Frontier analysis of Innovate UK data*

Note: *(1) Based on actual funding distributed rather than funding committed. (2) Funding measured on net basis (i.e. includes refunds to IUK). (3) Includes both private and non-private sector firms.*

[48] As noted above Innovation Loans and the Investment Accelerator Pilot do not appear in Figure 9 because they are new programmes that first distributed funding in 2018/19. We note that neither Innovation Loans or the Investment Accelerator Pilot are planned to involve large amounts of aid relative to CR&D, Smart or Catalyst. For example, Innovation Loans has a budget of £50 million over two years and given that funding will be distributed as loans rather than grants, the actual amount of aid will be significantly less than this.

[49] Note that the fact that funding was being distributed in 2017/18 doesn't necessarily mean that new grants were being handed out in 2017/18. Indeed, although a small number of recipients were still receiving Smart funding in 2017/18, no new Smart grants were handed out.

Figure 10 Total net funding distributed to private sector organisations (£m) by programme and year



Source: Frontier analysis of Innovate UK data

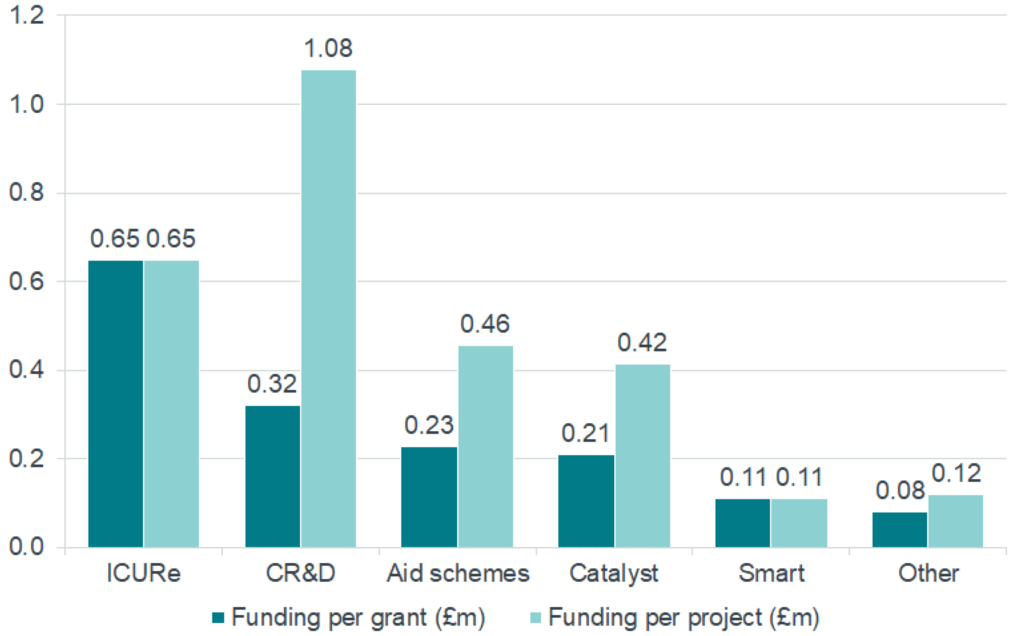
Note: (1) Based on actual funding distributed rather than funding committed. (2) Funding measured on net basis (i.e. includes refunds to IUK). (3) Includes private sector firms only.

In Figure 11 we report average (i.e. mean) funding committed per grant and per project between 2014/15 and 2017/18.[50] [51] Funding committed averaged £230,000 per grant for the aid scheme as a whole with some variation in this average across programmes. For example, the average Smart grant was only £110,000 whereas the average CR&D grant was £320,000.

[50] As noted above, we use funding committed here because we are considering funding on a per firm / per project basis.

[51] Because of the nature of our sample, average funding committed may include some projects that started before 2011/12 or projects that are still ongoing after 2017/18.

Figure 11 Average funding committed by grant / project in £ millions (2014/15 to 2017/18)



Source: Frontier analysis of Innovate UK data

Note: (1) Sample includes organisations that received in-scope IUK funding between 2014/15 and 2017/18. (2) Based on funding committed by Innovate UK. (3) A single recipient organisation can receive multiple grants if it received funding for multiple different projects. (4) Includes both private and non-private sector firms.

Given that there will be variation in grant size around the average, we also looked at the distribution of funding committed per grant awarded for different programmes. The results of our analysis suggest that differences across programmes in funding committed per grant awarded are driven by grants in the upper part of the funding distribution. Approximately half of the grants awarded under each programme are for less than £100,000. Smart programme grants are capped at a maximum of £250,000 per recipient organisation whereas amongst CR&D and Catalyst recipients, around one in five receive a grant above £250,000 and one in ten receive a grant above £500,000.

Figure 12 shows the distribution of Smart funding. There are three categories of Smart programme grant (Proof of Market, Proof of Concept and Development of Prototype) each of which will have their own maximum cap. In Figure 12 we can see three distinct funding bands:

- up to £25,000 (which contains the bottom 24% of recipients);
- £25,000 to £100,000 (the middle 42% of recipients); and
- and £100,000 to £250,000 (the bottom 35% of recipients).

The red circles in Figure 12 suggest bunching around these caps but there are also a substantial proportion of projects that receive funding below the relevant cap.

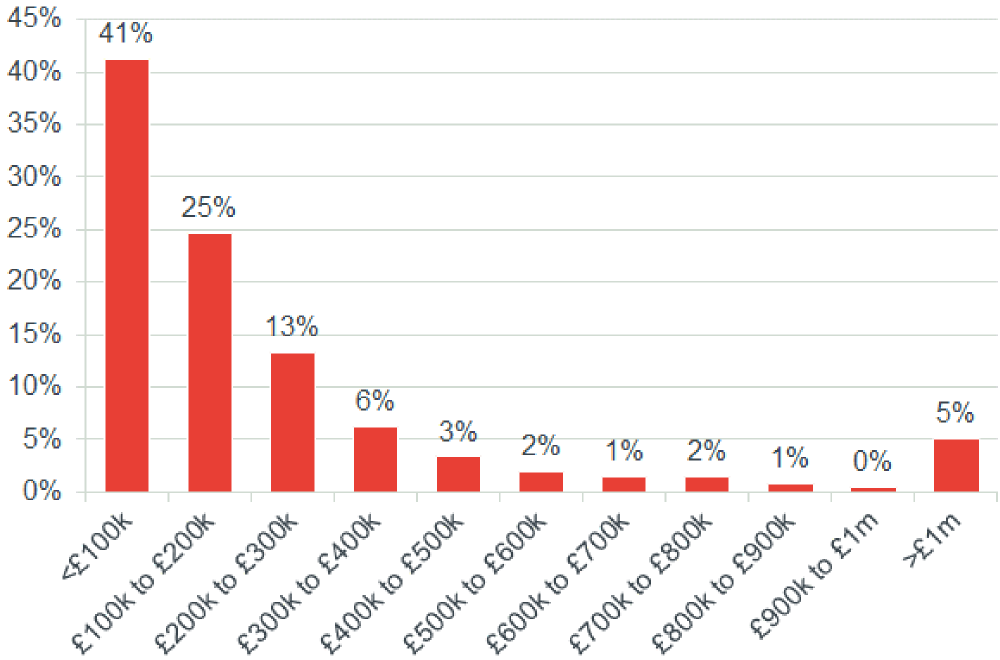
Equivalent distributions for the CR&D and Catalyst programmes are shown in Figure 13 and Figure 14 respectively.

Figure 12 Distribution of funding committed per grant in the Smart programme (2014/15 to 2017/18)

Source: Frontier analysis of Innovate UK data

Note: (1) Sample includes organisations that received in-scope IUK funding between 2014/15 and 2017/18. (2) Based on funding committed by Innovate UK. (3) A single recipient organisation can receive multiple grants if it received funding for multiple different projects. (4) Includes both private and non-private sector firms.

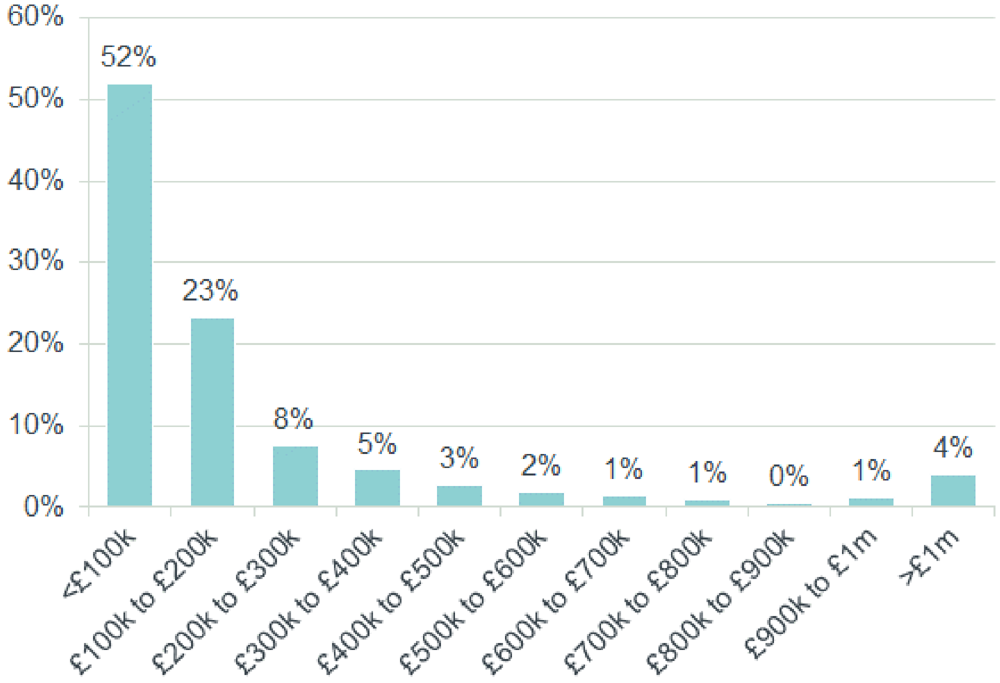
Figure 13 Distribution of funding committed per grant in the CR&D programme (2014/15 to 2017/18)



Source: Frontier analysis of Innovate UK data

Note: (1) Sample includes organisations that received in-scope IUK funding between 2014/15 and 2017/18. (2) Based on funding committed by Innovate UK. (3) A single recipient organisation can receive *multiple grants if it received funding for multiple different projects. (4) Includes both private and non-private sector firms.*

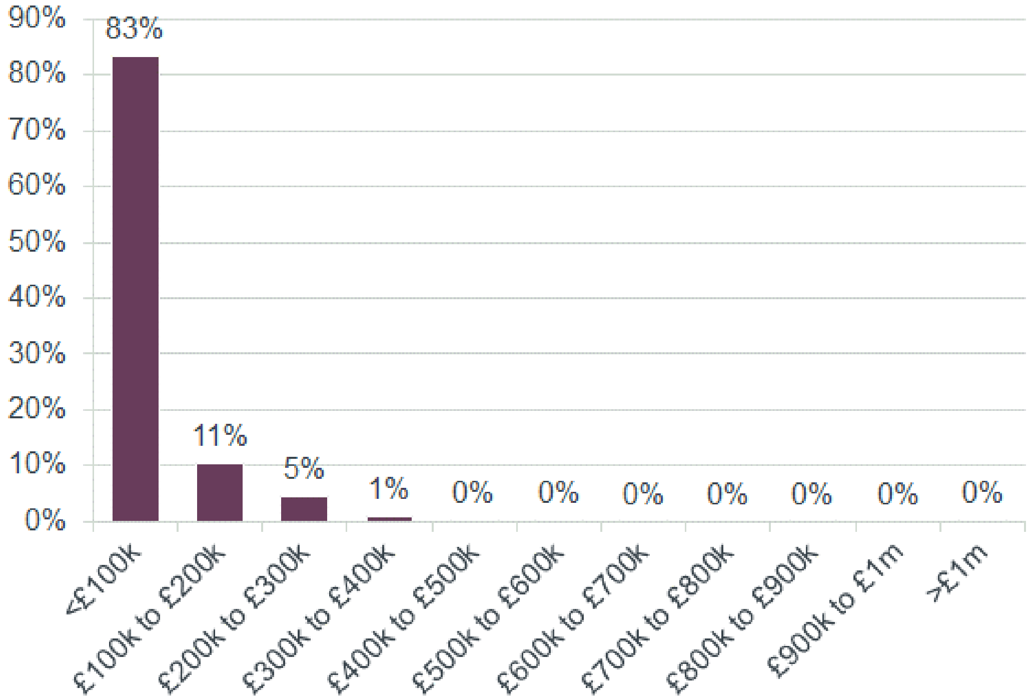
Figure 14 Distribution of funding committed per grant in the Catalyst programme (2014/15 to 2017/18)



Source: *Frontier analysis of Innovate UK data*

Note: *(1) Sample includes organisations that received in-scope IUK funding between 2014/15 and 2017/18. (2) Based on funding committed by Innovate UK. (3) A single recipient organisation can receive multiple grants if it received funding for multiple different projects. (4) Includes both private and non-private sector firms.*

Figure 15 Distribution of funding committed per grant in Other programmes (2014/15 to 2017/18)

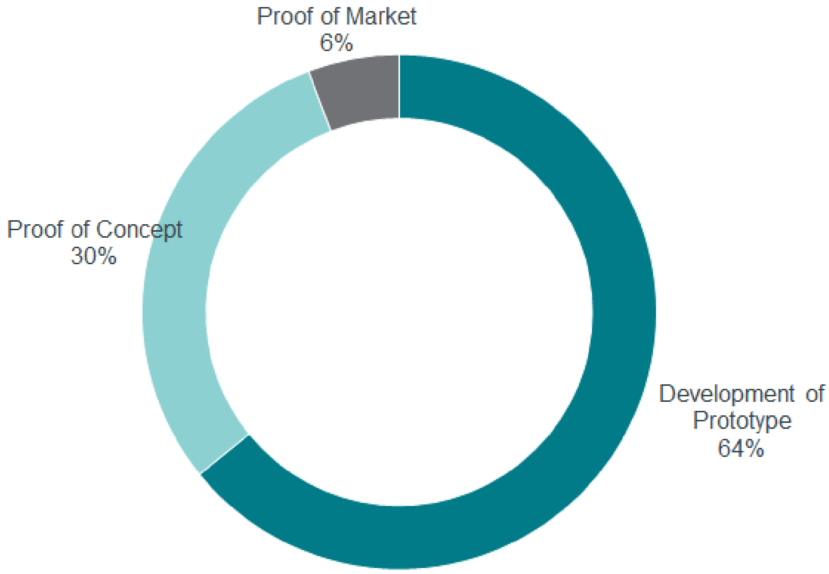


Source: Frontier analysis of Innovate UK data

Note: (1) Sample includes organisations that received in-scope IUK funding between 2014/15 and 2017/18. (2) Based on funding committed by Innovate UK. (3) A single recipient organisation can receive multiple grants if it received funding for multiple different projects. (4) Includes both private and non-private sector firms.

We have also looked at the breakdown of funding within programmes. For example, in Figure 16 we show how Smart funding of firms between 2014/15 and 2017/18 is split between Proof of Market, Proof of Concept and Development of Prototype. The largest category has been Development of Prototype which accounted for 64% of Smart funding of firms in this period.

Figure 16 Types of Smart funding distributed (2014/15 to 2017/18)

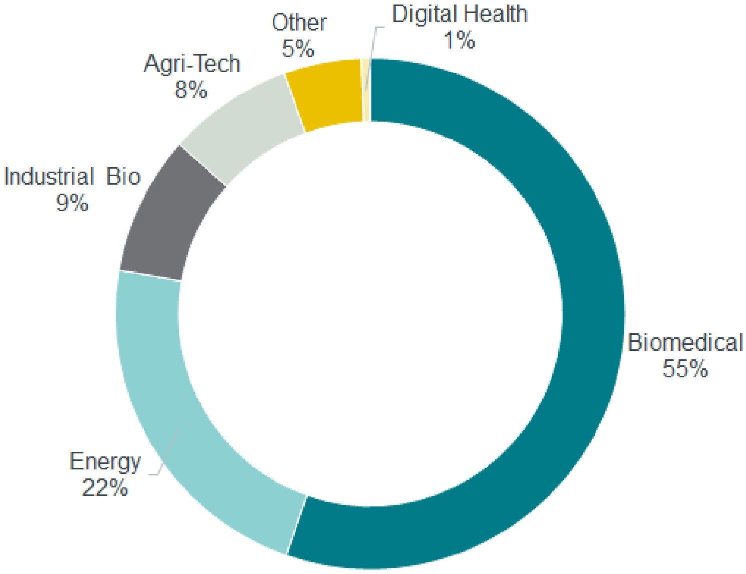


Source: Frontier analysis of Innovate UK data

Note: (1) Sample includes organisations that received in-scope IUK funding between 2014/15 and 2017/18. (2) Based on funding distributed by Innovate UK. (3) Funding measured on net basis (i.e. includes refunds to IUK). (4) A single recipient organisation can receive multiple grants if it received funding for multiple different projects. (5) Includes both private and non-private sector firms.

Similarly, Figure 17 shows that the majority of Catalyst funding distributed between 2014/15 and 2017/18 was through the Biomedical Catalyst (55%), which is the longest running series Catalyst funding competitions. The next largest part of the Catalyst programme was the Energy Catalyst which accounted for 22% of Catalyst funding.

Figure 17 Types of Catalyst funding distributed (2014/15 to 2017/18)

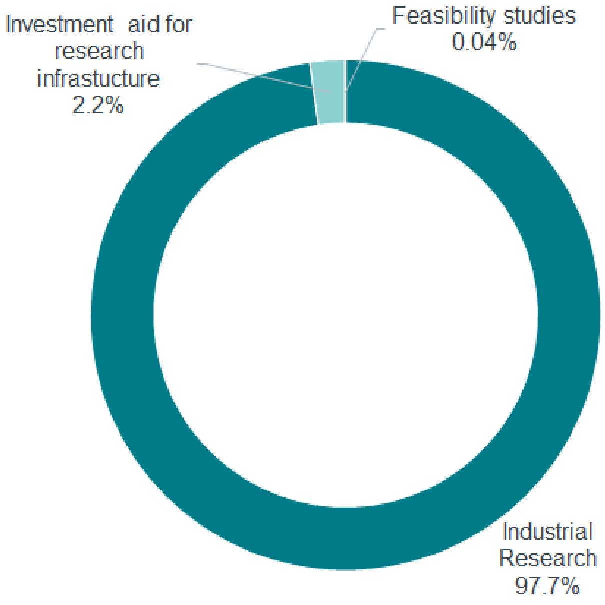


Source: Frontier analysis of Innovate UK data

Note: (1) Sample includes organisations that received in-scope IUK funding between 2014/15 and 2017/18. (2) Based on funding distributed by Innovate UK. (3) Funding measured on net basis (i.e. includes refunds to IUK). (4) A single recipient organisation can receive multiple grants if it received funding for multiple different projects. (5) Includes both private and non-private sector firms.

Finally, that 97.7% of CR&D funding between 2014/15 and 2017/18 was for Industrial Research[52] (Figure 18), while across all funding under State aid rules between 2014/15 and 2017/18 90% was for Industrial Research (Figure 19).

Figure 18 Types of CR&D funding distributed (2014/15 to 2017/18)

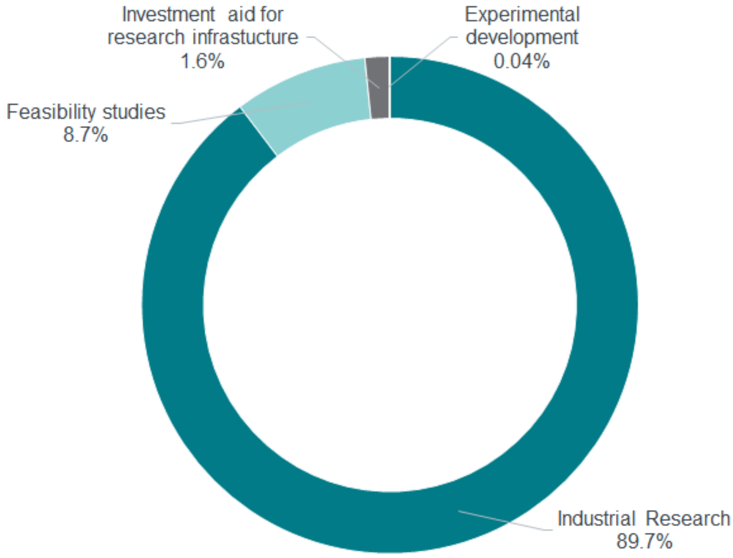


Source: Frontier analysis of Innovate UK data

Note: (1) Sample includes organisations that received in-scope IUK funding between 2014/15 and 2017/18. (2) Based on funding distributed by Innovate UK. (3) Funding measured on net basis (i.e. includes refunds to IUK). (4) A single recipient organisation can receive multiple grants if it received funding for multiple different projects. (5) Includes both private and non-private sector firms.

[52] In this context this means planned research or critical investigation to gain new knowledge and skills. This should be for the purpose of product development, processes or services that lead to an improvement in existing products, processes or services. It can include the creation of component parts to complex systems and may include prototypes in a laboratory or environment with simulated interfaces to existing systems, particularly for generic technology validation. https://www.gov.uk/guidance/innovate-uk-funding-general-guidance-for-applicants

Figure 19 Types of aid distributed across all programmes (2014-15 to 2017-18)



Source: Frontier analysis of IUK data

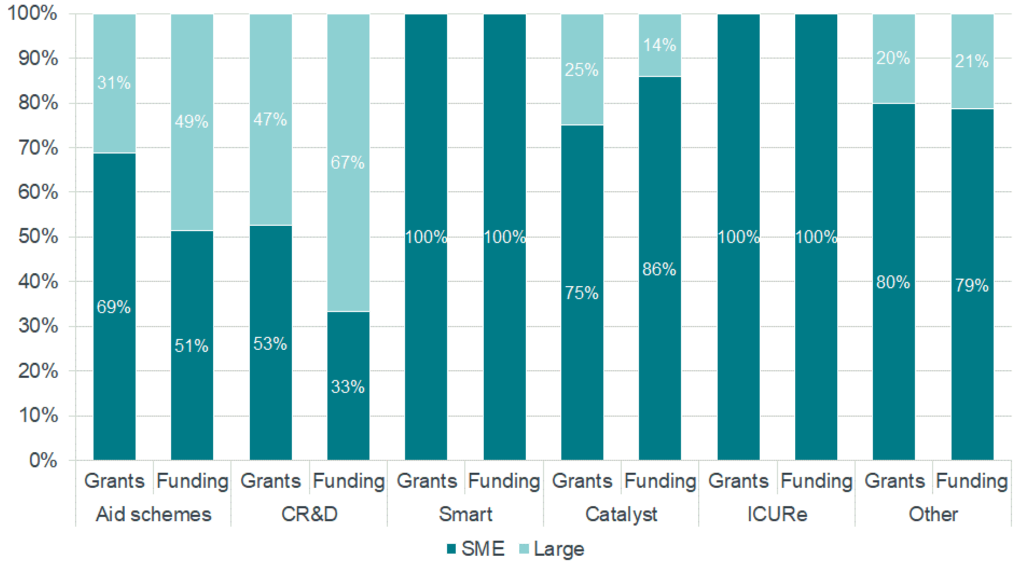
Note: (1) Sample includes organisations that received in-scope IUK funding between 2014/15 and 2017/18. (2) Based on funding distributed by Innovate UK. (3) Funding measured on net basis (i.e. includes refunds to IUK). (4) A single recipient organisation can receive multiple grants if it received funding for multiple different projects. (5) Includes both private and non-private sector firms.

Firm size

We also considered the characteristics of recipient firms. In Figure 20 we present a breakdown of the different sizes of private sector firms that receive funding. Overall we find that 69% of grants to private sector firms go to SMEs but there is variation across programmes: all Smart grants only go to SMEs[53] whereas only 53% of grants funded by the CR&D programme do.

[53] The 2% of Smart grants shown in Figure 20 going to large companies are data errors.

Figure 20 Proportion of grants and funding received by company size and programme between 2014/15 and 2017/18



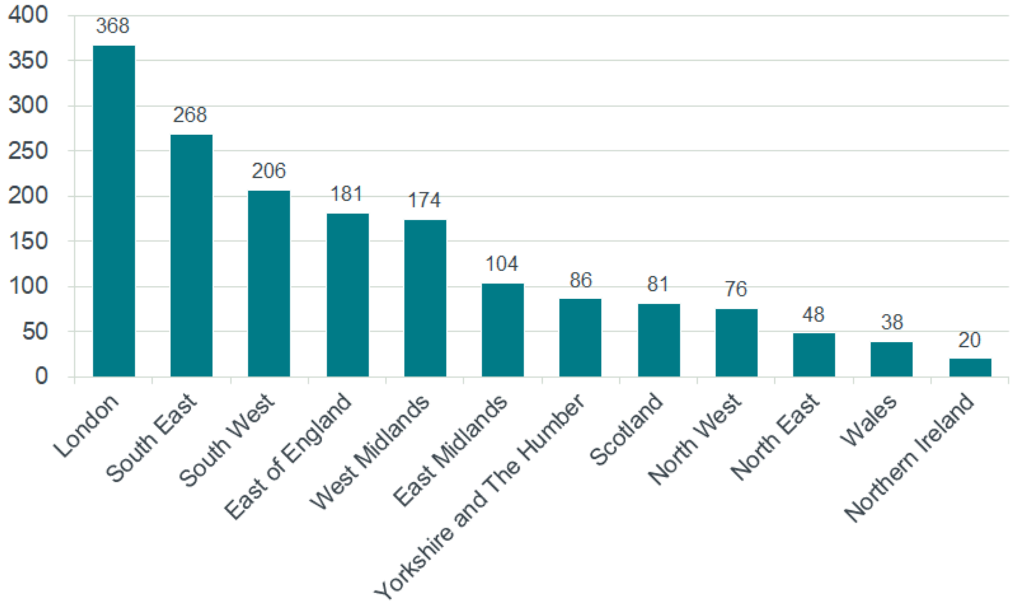
Source: Frontier analysis of IUK data

Note: (1) Sample includes private sector firms that received in-scope IUK funding between 2014/15 and 2017/18. (2) Based on funding committed by Innovate UK. (3) Funding measured on net basis (i.e. includes refunds to IUK). (4) A single recipient organisation can receive multiple grants if it received funding for multiple different projects. (5)In this chart, a small number of Smart grants have been manually changed to SME rather than large company to correct data errors.

Location

Figure 21 shows that grants go to firms located throughout the UK. All regions received at least £20 million in-scope funding between 2014/15 and 2017/18. Firms based in London attracted 22% of in-scope funding followed by firms based in the South East (16%).

Figure 21 Funding distributed to private sector organisations between 2014/15 and 2017/18 by location and programme (£ million)



Source: Frontier analysis of IUK data

Note: (1) Sample includes private sector firms that received in-scope IUK funding between 2014/15 and 2017/18. (2) Based on funding committed by Innovate UK. (3) Funding measured on net basis (i.e. includes refunds to IUK). (4) A single recipient organisation can receive multiple grants if it received funding for multiple different projects.

Firm activities

We know that certain programmes contained within the overall IUK scheme are focused on specific sectors. These areas of the economy align with UK priority areas. The UK Industrial Strategy sets out priority business sectors including life sciences, energy, and agricultural technology. This is consistent with IUK activity. The Biomedical Catalyst supports the life sciences sector, and the Low Carbon Vehicle competition within the CR&D programme supports decarbonisation of the energy sector.

The main aim of most IUK programmes is to assist the commercialisation of innovative products and services. However, non-commercial objectives are also achieved through the successful execution of supported projects. For example, the Biomedical Catalyst facilitates the development of innovative medical products and services. As part of this process, results of clinical trials are published, which contributes to the growth of the UK life sciences sector and ultimately the health of the population. Promoting good health is a core part of Europe 2020 as keeping people healthy and active for longer has a positive impact on productivity.[54]

The Agri-Tech Catalyst and the Sustainable Agriculture and Food CR&D programme both contribute to increasing the UK food supply through developing innovations that will increase agricultural yield. The EU is also allocating resources to encourage innovation in agriculture, specifically Horizon 2020's Societal

[54] https://ec.europa.eu/health/europe_2020_en

Challenge 2 relates to 'Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the bioeconomy'.[55]

A further positive area of societal impact is the environment. The Low Carbon Vehicles Innovation Platform will contribute to reducing emissions, which has a positive environmental effect on air quality. Positive spillovers associated with the CR&D programme will reduce pesticide usage, improve building efficiency and reduce fossil fuel dependency. This is consistent with the EC's low carbon economy roadmap which seeks to cut greenhouse gas emissions to 80% below 1990 levels by 2050.[56]

[55] http://ec.europa.eu/programmes/horizon2020/en/h2020-section/food-security-sustainable-agriculture-and-forestry-marine-maritime-and-inland-water

[56] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0112&from=GA

3 EVALUATION METHODOLOGY

3.1 Questions of interest

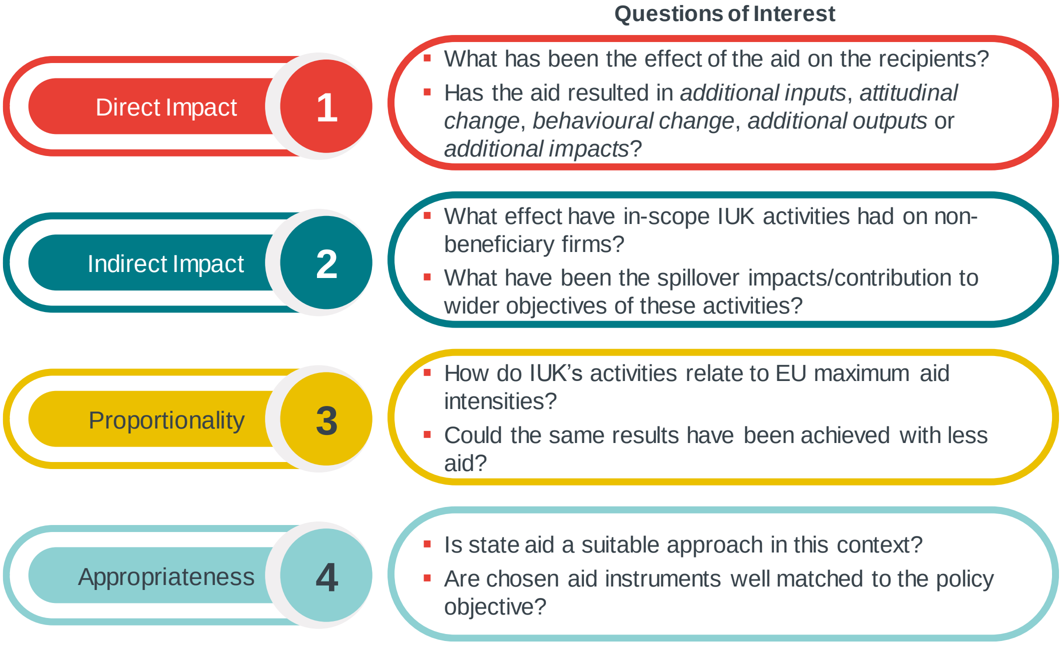
The funding period covered by this evaluation is 1 January 2015 to 31 December 2020. Therefore, given the timing of this final report, some of the most recent aid awarded will not feature in our evaluation.

This evaluation assesses the impact of the Innovate UK (IUK) State aid scheme across four dimensions:

1. Direct impact
2. Indirect impact
3. Proportionality
4. Appropriateness

We discuss what is meant by each of these dimensions in the following four sub-sections and present a visual summary below (Figure 22).

Figure 22 Dimensions of impact



Source: Frontier based on EC Common Methodology (EC, 2014 A)

3.1.1 Direct impact description

The direct impact of the IUK scheme refers to the effect of the aid on the beneficiaries. We explore whether the aid significantly altered the incentives of beneficiaries and/or whether the funding influenced the situation beneficiaries found themselves in.

The existence of certain types of direct impact resulting from the IUK scheme can also help us to understand whether the schemes are likely to distort competition. As stated in the European Commission's (EC) common methodology, aid which provides no direct incentive effect can be assumed to be distortive as it provides beneficiaries in question with windfall gains (EC, 2014 A).[57]

We will be answering five specific questions to understand the direct impact of the aid. These questions cover inputs, activities, outcomes and impacts, which mirror a typical logic model structure. We list these questions in Figure 23 below.

Figure 23 Specific questions relating to direct impact

Question	Explanation
Has there been any input additionality?	Explore whether the aid enables beneficiaries to raise other forms of finance more easily.
Has there been any attitudinal additionality?	Explore whether the aid has changed beneficiaries' attitudes and understanding around innovation.
Has there been any behavioural additionality?	Explore whether the aid has changed beneficiaries' actions such as increasing levels of innovation activity or increasing implementation of innovation strategies.
Has there been any output/outcome additionality?	Explore whether there have been increases in outcomes such as increased employment of skilled labour or increased turnover as a result of the aid.
Has there been any impact additionality?	Explore whether there have been increases in final impacts such as increased value added of beneficiary firms as a result of the aid.

Source: IUK

These impacts are likely to occur sequentially. Changes to inputs and attitudes of beneficiaries are likely to occur in advance of impacts on behaviour, outputs and impacts. Even if robust evidence of impacts at the later stages of the logic model are not yet evident, the existence of impacts at earlier stages is a necessary but not a sufficient condition for the effective operation of the aid scheme.

3.1.2 Indirect impact description

Indirect impacts refer to the effects of the IUK scheme on non-beneficiary firms or the wider economy. These indirect effects can be either positive or negative.

Positive indirect effects could come about if the IUK aid scheme leads to beneficial spillover effects on other firms via the dissemination of knowledge or the establishment of new supplier or customer relationships, for example.

Negative indirect effects could come about if the scheme alters the incentives of non-beneficiary firms, which in turn could lead to a distortion in competition. For example, the aid could theoretically lead to displacement of economic activity from one region to another (EC, 2014 A).[58]

57 See p 7, http://ec.europa.eu/competition/state_aid/modernisation/state_aid_evaluation_methodology_en.pdf

58 See p 17, http://ec.europa.eu/competition/state_aid/modernisation/state_aid_evaluation_methodology_en.pdf

3.1.3 Proportionality description

The EC's Common Methodology for State Aid Evaluation states that an evaluation could examine the proportionality of the chosen aid instrument (EC, 2014 A).[59] Aid is judged to be proportionate only if the same result could not be reached with less aid.

The EC has set out guidelines on the maximum aid intensities (expressed as a percentage of eligible costs). According to the Common Principles for an Economic Assessment of the Compatibility of State Aid under Article 87.3 produced by the EC, aid is normally deemed to be proportionate if these maximum aid intensities are respected (EC, 2009 A). Maximum aid intensities are set out by the EC in the Framework for State Aid for Research and Development and Innovation (EC, 2014 C). Aid can cover a higher proportion of costs when the recipient is a smaller firm and the project is related to fundamental research as opposed to applied research.

3.1.4 Appropriateness description

State aid needs to be appropriate to the task in hand. State aid is not the only policy instrument that Member States can use to promote innovation (EC, 2009 A).[60] For example, a Member State could instead undertake demand-side changes such as regulation or direct provision of goods and services.

State aid can also come in several forms. Aid which is designed to promote innovation can be awarded in various forms such as grants or loans. The most appropriate form of State aid will be the State aid instruments which achieve the overall objectives with the fewest distortions to competition and trade.

Our evaluation therefore assesses:

1. The extent to which State aid is a suitable approach to dealing with the issues that the IUK scheme sets out to address; and
2. The extent to which the chosen State aid instruments are well matched to the public policy objective.

3.2 Overall approach

The methodology used to evaluate the IUK aid scheme is set out in the published evaluation plan (EC, 2015 A). IUK is fully committed to understanding and improving the effectiveness and efficiency of its activities (IUK, 2018 A). To support this objective IUK have commissioned a series of evaluations[61] which explore the impact of specific programmes within the overall aid scheme.[62] These evaluations of specific programmes within the overall IUK aid scheme allow for detailed component level examination.

These component level evaluations fulfil large parts of the evaluation plan as they seek to address the same questions that the EC poses for specific programmes

[59] See p 4, http://ec.europa.eu/competition/state_aid/modernisation/state_aid_evaluation_methodology_en.pdf

[60] See p 11, https://ec.europa.eu/competition/state_aid/reform/economic_assessment_en.pdf

[61] A full list of relevant material is available in Annex A.2.

[62] As well as evaluating other activities which do not fall under EC State Aid regulations.

rather than the scheme as a whole. Our role as the independent single evaluation body is to carry out a single scheme-wide evaluation. This involved two major strands of work:

- We drew out relevant aspects within the existing evidence base to help with answering key questions of interest relating to direct impact, indirect impact, proportionality and appropriateness. The evidence synthesis is not a literature review of tangential evidence, but rather it forms a core part of the evaluation. Our synthesis is not simply a summary of findings but also draws out cross-cutting themes which have emerged across the scheme. These headline messages are supported by detailed information relating to specific programmes and sub-programmes where appropriate. We have included a full list of the evidence sources used in Annex A.2. In addition to evaluation reports, we drew on IUK submissions to the EC and internal documents held by IUK relating to scheme design. As we outline above, the relevant funding period for this piece of work is 1 January 2015 to 31 December 2020. However, in our synthesis we have included specific evaluation evidence which related to funding awarded as part of in-scope programmes prior to 2015. We took this decision to ensure that no potentially useful evidence was omitted. Where possible we have given priority to more recent findings when synthesising across multiple sources.
- We also undertook our own analysis to augment the existing evaluations with additional evidence of indirect effects, proportionality and appropriateness carried out at the scheme level. This was primarily to explore indirectly impacts on competition and trade which were not considered in depth as part of the component level evaluations. This is described in detail in the relevant sections below.

The evaluation plan notes that different methods will be used to address different aspects of the scheme’s impact. In the following sub-sections we set out the methodologies that we used across each of the four dimensions of impact. We present this in summary form in Figure 24 below.

Figure 24 Summary of methodologies used

Dimension	Programme/component level	Scheme level
Direct impact	■ Econometric comparison of recipient firms and non-recipient firms using survey data □ Propensity score matching □ Difference-in-difference analysis □ Regression discontinuity analysis ■ Econometric analysis of administrative data to assess business performance of funded firms ■ Stakeholder engagement and case studies ■ Analysis of management information	■ Synthesis of programme level findings

Dimension	Programme/component level	Scheme level
Indirect impact	▪ Identification of spillovers via self-report surveys of successful and unsuccessful applicants ▪ Case studies of pairs of beneficiary and non-beneficiary firms	▪ Synthesis of programme level findings ▪ Identification of affected markets via linking of IUK management information to secondary data ▪ Development of hypotheses and selection of appropriate data □ Stakeholder engagement □ Cross-sectional examination of recipient firms in each market □ Time series analysis of competitive dynamics
Proportionality	▪ Exploration of direct impact effect sizes for grants of different sizes ▪ Summarise evidence relating to IUK decision-making process	▪ Analysis of IUK monitoring data to determine aid intensity of each in-scope project
Appropriateness	▪ Breakdown of IUK funding by scheme component	▪ Applicability of State aid in the current context ▪ Comparison of UK activities to other EU Member States ▪ Description of IUK portfolio of support mechanisms

Source: Frontier and existing evidence

Note: Further detail on the methods used in existing evaluations is provided in Section 4.2.

3.3 Direct impact methodology

3.3.1 Evaluation challenges in the current context

As set out in IUK's (2018 A) Evaluation Framework there are several issues which need to be considered when carrying out evaluation work in the context of R&D&I.

- **Data availability**: Accurate and timely data on measures of interest such as firm level R&D intensity are not always available as part of secondary datasets. This means that evaluations of innovation support programmes often have to rely on primary data collection. This can, depending on the level of resources available for evaluation, have implications for sample size and ultimately, statistical power.
- **Fluidity**: The organisations in receipt of innovation support are widely varied and include beneficiary companies that are rapidly evolving. This can mean that tracking specific recipients over time is difficult (IUK, 2018 A).
- **Low observability**: The primary output of innovation support is the creation of new knowledge. This cannot be easily observed or tracked directly. Instead it may be necessary to measure whether new products, services and processes

have been developed, which are the observable manifestations of the new knowledge.

- **Attribution**: As we describe in Chapter 12, the IUK aid scheme is one part of a complex science and innovation ecosystem that exists in the UK. This implies that organisations who benefit from IUK funding may also be interacting with other forms of support available at national and sub-national levels. Therefore, identifying the contribution of any single programme or aid scheme is difficult.
- **Timing**: IUK supports organisations at all stages of the commercialisation process via programmes that often take place over several years. The emergence of final outcomes, especially for early-stage innovation support, which is relatively far away from the market, can take a long time. This supports the need for longitudinal long-term research projects, several of which are currently underway, to assess the impact of IUK's scheme,.

3.3.2 Summary of methods used to generate direct impacts and assessment of robustness

Sixteen independent programme level evaluations have been commissioned by IUK[63] to form core components of the scheme evaluation with a particular focus on direct impacts. Rather than repeat the details of each individual evaluation, which can be found within the appended evaluation reports, this report synthesises the methodologies and associated results, adding supplementary scheme level analysis where relevant. These individual evaluations cover every programme which makes up the overall aid scheme and therefore allow for a full examination of all possible direct impacts.

A range of methods have been used to measure direct effects across the associated programme level evaluations.

- The impact evaluation of the **Biomedical Catalyst** (Ipsos MORI, 2016 B) made extensive use of econometric techniques, comparing successful and unsuccessful applicants to create a credible counterfactual. These techniques included propensity score matching to balance characteristics of successful and unsuccessful applicants and regression discontinuity design to compare applicants who had narrowly missed out on funding to those who had received funding but were close to missing out.
- The evaluation of the Strategic Investments in Low Impact Building (Ipsos MORI, 2017 A) (which formed part of the **CR&D** programme) also used regression discontinuity techniques to establish the causal impact of the programme on successful recipients relative to unsuccessful recipients.
- SQW (2015) carried out an evaluation of the **Smart** programme, which involved difference-in-difference analysis to produce quasi-experimental estimates of impact. Again, unsuccessful applicants served as the counterfactual.
- The evaluation of the **ICURe** (Ipsos MORI, 2018 B) also employs an econometric difference-in-difference analysis to explore the causal effects of the programme.

[63] Several of these evaluations lead to multiple outputs. We have included a full list of the evidence sources used in Annex A.2.

- The existing evaluation evidence currently available in relation to **Innovation Loans Pilot (ILP)** and **Investment Accelerator Pilot (IAP)** is still interim in nature. Therefore, the robust econometric techniques described above have not been applied to date. These programmes are relatively new and further follow-up evaluation work is planned to address this.

These methods are in line the published evaluation plan (EC, 2015 A),[64] which specifically referred to difference-in-difference analysis and regression discontinuity design. As noted above, there are significant challenges associated with carrying out evaluation work in the context of innovation support. The commissioned evaluations make excellent use of mixed method approaches to overcome these issues. Triangulating across several different types of analysis helps to increase confidence in findings and, in some cases, explain how effects were generated.

Almost all evaluations initially set out a theory of change underlying the relevant investment programme and describe the underlying rationale for intervening. This is very important in setting the overall direction of the evaluation and selecting appropriate metrics and methods.

Generally, a combination of approaches are then employed including:

- analysis of management information;
- stakeholder consultation;
- a survey of successful applicants and unsuccessful applicants (to serve as a counterfactual);
- case studies across each type of grant awarded; and
- data linking of applicants to sources of secondary data.

The existing evaluation work already carried out involved extensive stakeholder engagement exercises in a number of cases. For example, the evaluation of the Collaborative R&D programme (PACEC, 2011) involved surveys and interviews with 336 CR&D participants and 205 unsupported bidders.

We present further detail on the specific methodologies employed across each evaluation in Section 4.2.

The summary in Figure 25 shows that most of the studies included in our synthesis would be classified as Level 4 on the SMS.[65] This implies that a credible counterfactual was created and advanced econometric techniques were used to ensure comparability between the beneficiary group and the control group. This means that we can have a high level of confidence in the findings generated in relation to scheme direct impacts in this report, and the reported effects are likely to be causal.

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[64] See p 4, https://ec.europa.eu/competition/state_aid/cases/256732/256732_1703219_80_2.pdf

[65] We draw on the Maryland Scientific Methods Scale (SMS) (Sherman et al., 1998), which is commonly used to characterise the approach used by studies. The SMS is a five-point scale, where higher values correspond to more robust evaluations. Level 1 methods assess outcomes after an intervention but only for those affected and no comparison groups are used. Methods which are categorised as Level 3 would involve the use of a counterfactual group which did not receive any intervention. The most robust methods involve the random assignment of treatment to comparable units. Given that pure experimental methods are not feasible in the current context, methods will range from Level 1 to Level 4. Further detail on the SMS is provided in Annex A.1.

When we report our findings, we do not only categorise studies according to their SMS category. We also critically assess existing evidence and comment on specific methods used and their associated advantages and possible limitations.

A small number of studies were scored as either a 2 or a 3 on the scale, which implies that we cannot have the same level of confidence in the findings. The lower scores were generally because the studies either did not include a control group or relied on univariate analysis rather than attempting to control for differences between beneficiaries and unsuccessful applicants. In several cases there were interim rather than final reports and in other cases more robust direct impact evidence relating to the programme in question is available from other evaluation reports.

Given the current context, we believe that these methods represent appropriate efforts to establish reliable causal impacts. It is in our view unlikely that reasonable alternative methodologies could have been implemented that would lead to the estimation of more reliable causal impacts.

Figure 25 Summary of direct effect robustness

Programme	Evaluation	SMS Rating
CR&D	Evaluation of the Collaborative Research and Development Programmes: Final Report (PACEC, 2011)	3
CR&D	Strategic Investments in Low Impact Building: Impact Evaluation (Ipsos MORI, 2017 A)	4
CR&D	Strategic Investments in Sustainable Agriculture and Food Evaluation (Ipsos MORI, 2017 B)	4
CR&D	The Low Carbon Vehicles Innovation Platform: An Impact Review (IUK, 2015)	2
CR&D	TSB Feasibility Studies Programme: Evaluation Findings (WECD, 2013)	4
CR&D	Advanced Propulsion Centre: Impact and Economic Evaluation Scoping (Ipsos MORI, 2016 A)[66]	4
CR&D	Advanced Propulsion Centre: External Process Evaluation (Ipsos MORI, 2018 A)[67]	Not applicable
CR&D	The Aerospace Technology Institute: Scoping Study to Establish Baselines, Monitoring Systems and Evaluation Methodologies (SQW, 2016 B)[68]	4
CR&D	Evaluation of ATI Aerospace R&D Programme. Process and Implementation Review (Ipsos MORI, 2017 C)[69]	Not applicable
Catalyst	Biomedical Catalyst Evaluation: Process Evaluation and Baseline Impact Evaluation (Ipsos MORI, 2016 B)	4
Catalyst	Process Evaluation of Catalyst Programmes: Interim Progress Report (SQW, 2017 C)[70]	Not applicable

66 Rating refers to proposed economic evaluation which is scoped out in this report and is yet to be completed.

67 Process evaluation which is not designed to produce robust direct impact findings.

68 Rating refers to proposed economic evaluation which is scoped out in this report and is yet to be completed.

69 Process evaluation which is not designed to produce robust direct impact findings.

70 Process evaluation which is not designed to produce robust direct impact findings.

Programme	Evaluation	SMS Rating
Catalyst	Process Evaluation of the Catalyst Programmes: A Final Report to Innovate UK (SQW, 2019 D)	Not applicable
Smart	Evaluation of Smart: Impact and Process Evaluation (SQW, 2015)	4
Smart	Evaluation of Smart: On-going Evaluation – Year 1 Report (SQW, 2016 A)	3
Smart	Evaluation of Smart: On-going Evaluation – Year 2 Report (SQW, 2017 A) [71]	Not applicable
Smart	Evaluation of Smart: On-going Evaluation – Final Report (SQW, 2019 B)	4
ICURe	ICURe Evaluation: Final Evaluation Report (Ipsos MORI, 2018 B)	4
Innovation Loans Pilot	Evaluation of Innovation Loans: Early Interim Report (SQW, 2019 A)	3
Investment Accelerator Pilot	Investment Accelerator Pilot Evaluation: Deliverable 3 Interim Impact Report (SQW, 2019 C)	2

Source: Frontier based on evidence review

3.4 Indirect impact methodology

3.4.1 Positive spillovers

The existing individual evaluations do contain relevant information on whether:

- there have been any spillover impacts on customers, suppliers, competitors and the wider economy;
- the aid has resulted in any unanticipated outcomes; and
- the aid has impacted on any wider policy objectives.

We synthesise these findings across the entire scheme. This existing evidence base is primarily based on qualitative research which was also included in the evaluation plan (EC, 2015 A).[72]

3.4.2 Scheme-wide trade and competition approach

As noted above, State aid can lead to negative indirect effects if it results in a distortion of competition within or between Member States. An assessment of the competition impact of the scheme is a key requirement of State aid methodology, but one that is not adequately covered by the individual programme level evaluations commissioned by IUK. For this reason, we have carried out a holistic evaluation of the potential competition effects of the IUK aid scheme using a methodology which is based on published EC guidelines (EC, 2014 A) and an EC

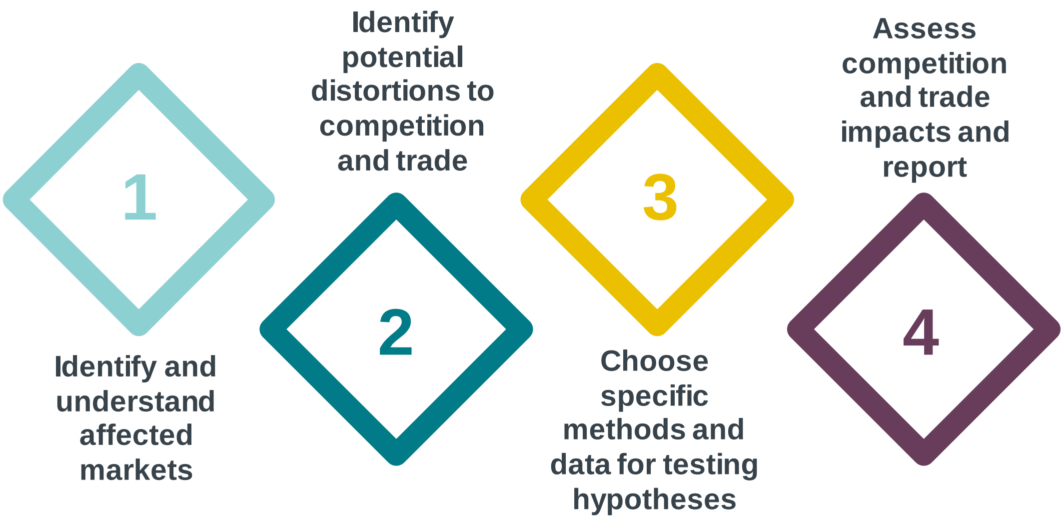
[71] Process evaluation which is not designed to produce robust direct impact findings.

[72] See p 4, https://ec.europa.eu/competition/state_aid/cases/256732/256732_1703219_80_2.pdf

report on ex post assessment of the impact of State aid on competition (Oxera, 2017).

We present the steps involved in the scheme-wide analysis of competition in Figure 26 below and provide further detail on each step in the following sub-sections. Each stage of this methodology is underpinned by our understanding of the aid scheme which we presented in Chapter 2.

Figure 26 Approach used for evaluation of indirect effects at scheme level



Source: *Frontier, drawing on Common Methodology for State Aid Evaluation (EC, 2014 A) and EC report on Ex Post Assessment of the Impact of State Aid on Competition (Oxera, 2017).*

Identify and understand affected markets

As we showed in Chapter 2, the IUK aid scheme distributed over 9,000 grants to private sector businesses between 2014/15 and 2017/18. Since these businesses operated across a wide range of different markets it is not practical or cost effective to analyse every market that contains firms who received in-scope funding in detail. Instead, we adopted a proportionate approach, selecting four representative markets and evaluating the competition impacts on these markets in detail.

We selected a shortlist of markets to focus on. This selection process was primarily based on the importance of IUK aid to each market. Specifically, we examined markets which have received a relatively large amount of IUK funding and feature a large number of beneficiary firms.

To ensure data availability, we used market definitions contained within administrative datasets (which we outline in detail below). Therefore, we also wanted to focus on markets where the administrative definition is a reasonable proxy for an economic market. We discuss this further in Chapter 5.

Identify potential distortions to competition and trade

We then developed a series of testable hypotheses, which were tailored to each shortlisted market. The specific hypotheses we developed are informed by the competitive structure of the market, the role played by R&D in the market and the role of State aid in the market. They are also fully in keeping with the published evaluation plan (EC, 2015 A) and the EC's indirect impact tests which are set out in the Common Methodology for State Aid Evaluation (EC, 2014 A).[73]

We used descriptive quantitative analysis to explore the level of concentration within each of our shortlisted markets and analyse market dynamics. We also reviewed market reports and existing literature to consider the nature of competition in each market and to understand the relevant segments and sub-segments that exist. We discuss this further in Chapter 7.

We assessed these hypotheses against one or more counterfactuals which will proxy what would have happened in the absence of aid. We describe the methods used to create these counterfactuals below.

Choose specific methods and data for testing hypotheses

We then selected appropriate methods and data that allowed us to test the hypotheses developed across each of the markets. We used a mixed-methods approach to test the hypotheses, drawing on quantitative methods as well as stakeholder interviews.

Our quantitative analysis built on the descriptive overview of each market and covered all beneficiary firms in each shortlisted market. Each specific piece of analysis that we undertook was tailored to address a specific hypothesis. Specifically, we carried out:

- Cross-sectional examination of which firms in each market tend to receive aid:
  - Does the aid favour large firms or small firms?
  - Does the aid favour established firms or new entrants?
- Time series analysis of how the performance of funded and non-funded firms differs.
- Time series analysis of the significance of IUK funding as a proportion of all R&D carried out in each market.
- Time series analysis of patterns of exit and entry in affected markets during the relevant time period.
- Time series analysis of market concentration.

The analysis relied on numerous sources of data. Most notably:

- **IUK monitoring data** provides information on projects funded by IUK. For each aid recipient on each project, the data includes project details (project name, the programme the aid falls under, funding committed by IUK, start date, etc.) and demographic information on the recipient (location, type of organisation, etc.). A similar non-confidential dataset listing IUK projects is available online.[74]
- The **Business Structure Database (BSD)** provides longitudinal firm level data on variables such as employment, turnover and Standard Industrial Classification (SIC) code (UK Data Archive, 2006). It includes all UK businesses that are either VAT registered or have at least one employee paying income tax. Sources for the BSD include administrative data and business

[73] See p 38, https://ec.europa.eu/competition/state_aid/modernisation/state_aid_evaluation_methodology_en.pdf

[74] https://www.gov.uk/government/publications/innovate-uk-funded-projects

surveys.[75] The majority of our quantitative analysis comes from linking IUK monitoring data with the BSD. This allows us to determine the amount of in-scope aid received by each SIC code, describe the competitive structure of our chosen SIC code and track the turnover and employment of funded and unfunded firms over time. The BSD was explicitly included as a potential evidence source in the evaluation plan (EC, 2015 A).[76] In addition:

- Since the BSD does not provide organisation names for confidentiality reasons, we also used **FAME**, a longitudinal firm level financial reporting dataset produced by Bureau van Dijk Electronic Publishing (2019), to identify the names of organisations in our chosen markets that successfully and unsuccessfully applied for IUK funding.[77]
- Since the BSD does not contain information on R&D spending, we used the **UK Business Enterprise Research and Development** dataset to provide R&D expenditure at a SIC code level (ONS, 2019 A).[78]
- Since the BSD does not contain information on UK exports, we used the **UK Trade in Goods by Classification of Product by Activity** dataset to provide UK goods exports at a SIC code level (ONS, 2019 B).[79]

- **EPO (European Patent Office) annual report data** (EPO, 2019) provides information on the quantity of patents over time. The data includes a breakdown of the number of European patent applications filed and granted per EPO member country (all 28 EU Member States, plus ten global countries) and by each technology area for each year from 2009. The data includes direct European applications and international (PCT) applications that entered the European phase. The geographic origin is based on the country of residence of the first applicant listed on the application form, which is known as the first-name applicant principle. The definitions of the technology areas are based on the WIPO IPC technology definitions.[80]

Our qualitative analysis provided us with a richer understanding of possible competition distortions via semi-structured interviews with stakeholders covering a variety of perspectives. Specifically, we interviewed:

- Firms who applied for funding successfully and firms who applied for funding unsuccessfully. We identified these firms using the IUK monitoring data to determine which firms applied for in-scope aid during the period in question. We then contacted a sample of these firms for interview;[81]

75 Further information on the BSD is available here: https://beta.ukdataservice.ac.uk/datacatalogue/studies/study?id=6697

76 See p 5, https://ec.europa.eu/competition/state_aid/cases/256732/256732_1703219_80_2.pdf

77 Further information on the FAME dataset is available here: https://www.bvdinfo.com/en-gb/our-products/data/national/fame.

78 Further information on this dataset is available here: https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/researchanddevelopmentexpenditure/bulletins/businessenterpriseresearchanddevelopment/2017

79 Further information on this dataset is available here: https://www.ons.gov.uk/businessindustryandtrade/internationaltrade/datasets/uktradeingoodsbyclassificationofproductbyactivity

80 Further information on the annual report data can be found here: https://www.epo.org/about-us/annual-reports-statistics/statistics.html

81 In several cases, individual firms we engaged with had experience of both applying successfully and unsuccessfully for IUK funding.

- Industry representative bodies who can provide an overview of the relevant market and the potential effects of aid. We identified these firms via a combination of desk research into the relevant markets and engagement with IUK and the Department for Business, Energy and Industrial Strategy (BEIS); and
- Representatives from IUK and BEIS who oversaw the award of funding.

In total, we conducted interviews with 17 organisations. The number of interviews was evenly balanced across the shortlisted markets. A full list of interviewees is provided in Annex B.1. These interviews constituted specific deep dives into representative projects. They were not designed to be comprehensive in terms of all firms who could have been affected either directly or indirectly but rather to provide a greater depth of understanding of possible distortions to competition.

As we describe in Section 4.2 several large-scale primary data collection exercises have already been carried out at a programme level. In total, 3,845 surveys were completed by organisations. The majority of respondents were either successful or unsuccessful applicants for IUK funding. In addition, in-depth qualitative interviews were carried out with a further 460 organisations.[82] Again, these consultations tended to focus primarily on successful and unsuccessful applicants, but in some cases they also included consultations with IUK representatives and external stakeholders.

Our interviews were guided by the development of topic guides. These topic guides served as a starting point for our conversations and covered key areas of interest such as:

- background to the interviewees' organisation;
- the extent of the relevant firm's R&D activities before and after receiving or failing to receive IUK funding;
- the impact of IUK funding on a firm's attitudes and behaviours;
- the development of a firm's competitive position after receiving or failing to receive IUK funding; and
- alternative sources of R&D funding.

We have included a sample topic guide in Annex B.2.

Time period for evaluation of impacts on competition

In line with the evaluation plan agreed by the UK and EC,[83] we are conceptually interested in the possible impacts on competition for the period running from the start of 2015 to the end of 2020.

In practice, this is complicated by the fact that the micro level firm data that we use is released with a time lag – the latest wave of the BSD available for our analysis covers turnover and employment data largely for 2016/17. Focusing exclusively on funding distributed between 2015 and 2020 would give limited time for any effects on markets to materialise, especially given the early-stage nature of much of the aid provided by IUK.

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[82] Including case studies

[83] http://ec.europa.eu/competition/state_aid/cases/256732/256732_1703219_80_2.pdf

To give a longer period for effects to materialise, some of our quantitative analysis also considers aid distributed prior to 2015 and thus not 'officially' within scope. Since post-2015 funding is broadly a continuation of previously existing programmes;[84] we do not believe this has dramatically changed our findings.

Our qualitative analysis focuses on organisations that received funding in 2015/16 and some of the stakeholders interviewed had also received equivalent support prior to the official 2015-2020 period.

Further complications arise from the fact that the IUK aid scheme tends to support:

- R&D projects which in many cases are years away from market. This means that any distortions to markets may not be apparent for a long time. For this reason, we consider possible effects of the aid on market dynamics during the innovation and development process as well as on final product markets.
- Firms in new and often quickly evolving markets where many other factors are likely to affect competition. This means that isolating the effect of the aid scheme can be very challenging.

For these reasons, we cannot claim to pinpoint all possible causal effects of aid on competition at this stage. The published evaluation plan (EC, 2015 A) took these challenges into account and stated that the scheme's indirect impact would be analysed in a 'descriptive manner'.[85] However, our methodology is based on published EC guidelines (EC, 2014 A) and an EC report on ex post assessment of the impact of State aid on competition (Oxera, 2017). The conclusions of our trade and competition analysis do provide a reliable indication of scheme-wide indirect effects and we do not believe it is possible to design a reasonable alternative methodology that would establish comprehensive and reliable causal impacts.

3.5 Proportionality methodology

We carried out an analysis of IUK monitoring data covering the entire scheme to determine the aid intensity of each in-scope project. We present the results of this analysis, which compares the proportion of IUK-funded costs relative to stated EC guidelines, in Chapter 11.

In addition, as discussed in the evaluation plan, we collated available evidence on differences in impact according to the size of grant awarded. Our evidence review explores the process by which IUK makes its funding decisions. This helps us to judge the level of scrutiny applied to the aid awarded in relation to proportionality.

3.6 Appropriateness methodology

To assess the appropriateness of the scheme, we collected information on the range of support mechanisms currently in place both within and beyond the IUK aid scheme. We also explored other R&D support mechanisms currently in place in the UK. This is important as State aid is not the only policy instrument that

[84] Three of the programmes being evaluated – the Smart programme; the Catalyst programme and the CR&D programme – began distributed funding to organisations prior to 2015.

[85] See p 7, https://ec.europa.eu/competition/state_aid/cases/256732/256732_1703219_80_2.pdf

Member States can use to promote innovation (EC, 2009 A)[86] and will be more or less appropriate depending on the context in which it is used.

We also used IUK monitoring data to break down total funding awarded into a number of different programmes to determine whether emergent mechanisms were being utilised currently.

Finally, we reviewed existing evaluation evidence to assess whether it was possible to determine whether one type of instrument used by IUK (for example grants) was more or less effective than other instruments (for example loans).

[86] See p 11, https://ec.europa.eu/competition/state_aid/reform/economic_assessment_en.pdf

4 DIRECT IMPACT: RESULTS

In this section, we explore whether the Innovate UK (IUK) aid has had a significant effect on recipients: the beneficiaries. As we described in Chapter 3, we assess direct impacts across five specific areas, mirroring a typical logic model:

- input additionality;
- attitudinal additionality;
- behavioural additionality;
- output/outcome additionality; and
- impact additionality.

This allows us to explore whether the overall aid scheme and individual component programmes are changing beneficiary firms' incentives and influencing outcomes. The five specific areas were included within the published evaluation plan (EC, 2015 A).[87]

Firstly, we outline where existing direct impact evidence is available. We then present an overarching summary of the direct impact results before considering the individual programme-specific findings in depth.

4.1 Summary of direct impact evidence

4.1.1 There is a rich evidence base assessing direct impacts

Figure 27 Availability of direct impact evidence

	Input additionality	Attitudinal additionality	Behavioural additionality	Output/ outcome additionality	Impact additionality
Catalyst Programme	Evidence exists				Not yet assessed
Smart	Evidence exists				
ICURe	Evidence exists				
CR&D	Evidence exists				
Innovation Loans	Evidence exists				Not yet assessed
Investment Accelerator	Evidence exists				Not yet assessed

Source: Frontier based on review of existing evaluations

We have a rich source of information regarding the direct impacts of the scheme across all questions of interest (Figure 27).

While an extensive body of evidence on the impact of the Catalyst programme is currently available, impact additionality has not yet been assessed. It is currently

[87] See p 3, https://ec.europa.eu/competition/state_aid/cases/256732/256732_1703219_80_2.pdf

too early to robustly examine the impact of the programme on metrics such as gross value added (GVA) (Ipsos MORI, 2016 B). Further work is currently underway which will help fill this gap.

Similarly, while evidence has started to emerge on the direct impact of both the Innovation Loans Pilot (ILP) and Investment Accelerator Pilot (IAP), impact additionality has not yet been fully assessed for either programme (SQW, 2019 A, 2019 C). This is understandable given these two programmes are relatively new, and we expect this gap to be filled by forthcoming work.

It is also important to note that while some evidence is available for all other programmes across each of the areas of interest, the evidence base is not complete and will continue to develop in the coming years. In many cases, existing evidence provides an indication of early impact, which will be further refined in subsequent evaluation work.

The existing ICURe pilot evaluation (Ipsos MORI, 2018 B), which we draw on in this report, will be augmented by an additional follow-up evaluation.

As we describe below, there are numerous evaluations of specific CR&D programmes which are currently available and which we synthesise in this report. A retrospective evaluation of CR&D grants is also underway. An impact evaluation of both the Aerospace Technology Institute funding and the Advanced Propulsion Centre funding are due to be completed in 2019. Both sub-programmes are included within CR&D. This pipeline of future evaluations reinforces IUK's on-going commitment to robust evaluation and highlights its commitment to proactive improvement.

Our approach, which involves drawing on a large number of individual programme level evaluations, allows us to maximise the amount of longitudinal evidence currently available. A single more recently commissioned evaluation would be less conclusive in terms of final impacts.

4.1.2 Existing evidence shows the aid is having positive impacts across each area of interest

In Figure 28 below, we summarise the direct impact evidence. Each row represents a specific programme of the overall aid scheme and each column refers to one of the five areas of interest.

We find that certain programmes within the scheme were associated with consistently positive impacts on beneficiaries within certain areas of interest. In these cases, we filled the relevant cell with a tick symbol.

In other cases, the analysis undertaken shows that a programme had some positive effects on beneficiaries in one of the five areas, but no effect had yet materialised in other areas. When that occurred, we filled the relevant cell with a tick and a dash to represent the mixture of existing evidence.

On balance, the body of available evidence on direct effects of the scheme is very positive. Importantly, there were no cells across any of the programmes and areas of interest where evidence existed but where no positive effects could be observed.

The presence of positive incentive effects helps to mitigate against potential competition distortions. The EC's common methodology states that aid which provides no direct incentive effect can be assumed to be distortive as it provides beneficiaries in question with windfall gains.[88] This is clearly not the case in the current context as we consistently observe evidence of attitudinal and behavioural additionality.

Figure 28 Summary of direct impact evidence

	Input additionality	Attitudinal additionality	Behavioural additionality	Output / outcome additionality	Impact additionality
Catalyst Programme	✓	✓	✓ ⊖	✓ ⊖	Not yet assessed
Smart	✓	✓	✓ ⊖	✓ ⊖	✓
ICURe	✓	✓	✓	✓	✓
CR&D	✓	✓	✓	✓	✓
Innovation Loans	✓	✓	✓	✓ ⊖	Not yet assessed
Investment Accelerator	✓	✓	✓	✓ ⊖	Not yet assessed

✓ Consistent evidence of positive effects on beneficiaries

✓ ⊖ Some evidence of positive effects on beneficiaries, some evidence that effects have not yet materialised

Source: Frontier based on evidence synthesis

*Note: Evidence on the direct impact of the **Catalyst Programme** is based on: Biomedical Catalyst Evaluation: Process Evaluation and Baseline Impact Evaluation (Ipsos MORI, 2016 B), Process Evaluation of the Catalyst Programmes: Scoping Paper (SQW, 2017 B), Process Evaluation of the Catalyst Programmes: Interim Progress Report (SQW, 2017 C), Process Evaluation of the Catalyst Programmes: A Final Report to Innovate UK (SQW, 2019 D).*

*Evidence on the direct impact of **ICURe** is based on: ICURe Evaluation: Final Evaluation Report (Ipsos MORI, 2018 B).*

*Evidence on the direct impact of **Smart** grants is based on: Evaluation of Smart: Impact and Process Evaluation (SQW, 2015), Evaluation of Smart: On-going Evaluation – Year 1 Report (SQW, 2016 A), Evaluation of Smart: On-going Evaluation – Year 2 Report (SQW, 2017 A), Evaluation of Smart: On-going Evaluation – Final Report (SQW, 2019 B).*

*Evidence on the direct impact of the **CR&D programme** is based on: Evaluation of the Collaborative Research and Development Programmes: Final Report (PACEC, 2011), Strategic Investments in Low Impact Building: Impact Evaluation (Ipsos MORI, 2017 A), Strategic Investments in Sustainable Agriculture and Food Evaluation (Ipsos MORI, 2017 B), The Low Carbon Vehicles Innovation Platform: An Impact Review (IUK, 2015), Advanced Propulsion Centre: Impact and Economic Evaluation Scoping (Ipsos MORI, 2016 A), The Aerospace Technology Institute: Scoping Study to Establish Baselines, Monitoring Systems and Evaluation Methodologies (SQW, 2016 B), Evaluation of ATI Aerospace R&D Programme. Process and Implementation Review (Ipsos MORI, 2017 C).*

*Evidence on the direct impact of the **Innovation Loans** Pilot is based on: Evaluation of Innovation Loans: Early Interim Report (SQW, 2019 A).*

*Evidence on the direct impact of the **Investment Accelerator** Pilot is based on: Investment Accelerator Pilot Evaluation: Deliverable 3 Interim Impact Report (SQW, 2019 C)*

[88] http://ec.europa.eu/competition/state_aid/modernisation/state_aid_evaluation_methodology_en.pdf

To date the aid scheme has consistently impacted on earlier stages of the logic model

The first two columns of Figure 28 show that all five programmes consistently display both input and attitudinal additionality.

To assess input additionality, the individual evaluation reports have generally examined whether the aid has made it easier for beneficiary firms to access other forms of finance. To measure attitudinal additionality, existing evaluations have typically asked beneficiary firms, either as part of a survey or qualitative research, whether the scheme has led to the development of new skills or increased confidence.

It is not surprising that these areas exhibit consistent effects while the scheme has not had the same uniformity of impact on other aspects of direct impact. As we highlighted in Chapter 3, observable output and impact additionality will take longer to emerge.

Direct impacts at later stages of the logic model are evident in some cases but not in others

There is evidence that certain aspects of the scheme are having a positive impact on beneficiary firms' behaviour and outcomes. However, this is not the case across all metrics on every programme.

Behavioural additionality has been assessed using a range of measures. Existing evaluations examine the effect of the scheme on the commercialisation journey as well as exploring whether beneficiary firms have increased their level of R&D activity. Output additionality generally relies on business performance metrics, such as changes to turnover, employment or profits, that can be directly linked to the scheme.

This variation in impact is likely due to differences in the context within which specific programmes are delivered. Certain parts of the scheme are targeted at specific sectors such as the life sciences or low carbon vehicles whereas other programmes are open to applicants from any sector. Likewise, some programmes are targeted at small and medium enterprises (SMEs) where firms of any size can apply to other programmes. Also, as we outline below when considering the appropriateness of the scheme, some programmes are designed to support very early-stage research whereas others are designed to help firms who are relatively close to commercialisation. These important differences are likely to be driving some of the differential impact results.

The variation could also be due in part to the fact that the various programmes that make up the aid scheme are at different stages of their individual evaluation cycle.

Some impact additionality has been observed to date, although evidence is still preliminary in nature

There is some evidence available which suggests that the aid scheme is contributing to an increase in the value of beneficiary firms and is making a meaningful positive contribution to the wider economy. Different evaluations measured these impacts in different ways. The estimated impacts rely on certain assumptions and generally should be thought of as preliminary rather than final.

Several evaluations value the economic benefits associated with output additionalities described above, such as R&D spending or employment. In several cases the authors then compare these estimated benefits to the cost of programme delivery to calculate a cost benefit ratio.

Detailed evaluation evidence underpins our overall direct impact summary

The overall impact of each programme on each aspect of interest is summarised above. This summary represents our overall conclusions regarding existing evaluation evidence. However, it is important to be clear that within each cell there is, in some cases, a considerable volume of evidence. Therefore, in addition to considering overall direct impact across the scheme, it is important to critically examine direct impact findings across each of the evaluations carried out to date. We present this detailed direct programme level impact evidence in the next subsection.

4.2 Programme level direct effects

4.2.1 Smart

To date four evaluation reports relate directly to the Smart programme:

- Evaluation of Smart: Impact and Process Evaluation (SQW, 2015). A mixed-methods approach was used. Three core sources of evidence feed into our direct impact analysis:
  - IUK monitoring data covering Smart applicants (both successful and unsuccessful) over the evaluation period.
  - Surveys of beneficiaries and non-beneficiaries (whose application was judged to be nearly fundable). These surveys were undertaken by telephone and were completed with 293 firms that secured a Smart award and 189 firms that applied unsuccessfully for a Smart award. The survey covered the R&D experience of the firm, the reason for approaching Smart, the progress of the projects and measures of business performance.
  - Case studies with successful recipients.

  The direct effects we summarise below arise primarily from the survey results. We can have a high level of confidence in the findings as robust methods were used to compare the successful and unsuccessful applicants. Specifically, weightings were applied to the survey data to account for differences between survey sample and population. When analysing the survey data, the authors combined a quasi-experimental method applying difference-in-difference analysis with self-reported estimates of impact. All direct effects are based on self-reported data and are therefore subject to reporting error optimism bias and uncertainty. Response bias may also be a factor.

- Evaluation of Smart: On-going Evaluation – Year 1 Report (SQW, 2016 A). This report is part of a longitudinal evaluation of the Smart programme. The Year 1 report in 2016 provides a 'baseline' assessment, drawing on a first wave of survey research with companies supported by Smart awards and companies that applied to Smart but were not awarded a grant. Direct impact estimates contained in the Year 1 report are based solely on self-reported effects which can be calculated by analysing the first wave of survey data from companies that received an award and companies that did not. The survey assesses what would have/has happened with/without a Smart award in terms of project additionality and outcome additionality. In total, 741 applicants completed the first wave of the survey. As the final report (described below) is now available, we do not report interim results from this preliminary output below.

- Evaluation of Smart: On-going Evaluation – Year 2 Report (SQW, 2017 A). This report focuses on evidencing the spillover effects from Smart grants, drawing on in-depth interviews with supported companies and indirect beneficiaries such as suppliers and customers that may have benefitted from spillovers. The evidence contained within this report is not used to assess direct impacts.
- Evaluation of Smart: On-going Evaluation – Final Report (SQW 2019 B). This report is the final output of the evaluation. The report uses four perspectives to assess the outcomes and impacts of the Smart grants (three of which adopt a quasi-experimental design):
  - survey-based difference-in-difference analysis comparing overall business performance of beneficiary firms with that of unsuccessful applicants;
  - survey-based self-reported additionality analysis focused on direct effects of Smart on employment and turnover to date of beneficiaries;
  - econometric comparison of business performance of beneficiaries and unsuccessful applicants using secondary data; and
  - econometric comparison of business performance of beneficiaries and an external control group using secondary data.

  This robust combination of methods allows us to have a high level of confidence in the findings.

Input additionality

We know that all Smart grants required private match funding. Specifically, £111 million of private sector R&D investment was leveraged by Smart grants of £91 million (SQW, 2015). This is reinforced by survey evidence. 65% of beneficiary firms indicated that Smart had made raising finance easier. However, no comparison group was surveyed on the same topic, which limits our ability to determine whether all of this effect was causal and assess its magnitude (SQW, 2015).

Attitudinal additionality

We find that three-quarters of beneficiary firms reported that the Smart project had improved staff skills and knowledge or led to an improved understanding of market position and opportunities. There is no direct comparison to non-beneficiaries available. Subsequent analysis of other responses by non-beneficiary firms did suggest that approximately half of this effect may be additional (SQW, 2015). This helps to increase our confidence in this finding. However, it is still not entirely straightforward to determine causality and precisely quantify the effect size.

Follow-up surveys of Smart award holders revealed wider effects on business capabilities and behaviours (such as changes to management practices, improved awareness of customers/markets and increased confidence skills and capabilities) from the award. Finally, we see that approximately one-third of interviewees identified that Smart had positively influenced their attitude towards R&D and investment. Again, no comparison group was surveyed on the topic (SQW, 2019 B). As these effects are solely based on the responses of beneficiary firms, we cannot be fully confident that they are additional. However, it is reassuring that the most recent findings are generally in keeping with the earlier evaluation results.

Behavioural additionality

Using difference-in-difference modelling we find that there is no evidence of a statistically significant effect overall on R&D expenditure for the entire sample of surveyed firms. However, there is evidence of a significant positive effect on R&D expenditure for firms younger than one year (SQW, 2015).

Difference-in-difference modelling included as part of the final evaluation report (SQW, 2019 B) also showed that the Smart programme did not lead to an overall increase in R&D activity. The use of sophisticated econometric techniques allows us to have a high degree of confidence in this finding.

Outcome/output additionality

To assess the outcome/output additionality of the Smart programme, we rely exclusively on the final evaluation report (SQW, 2019 B) as this provides the most up-to-date evidence source and covers all areas assessed by previous evaluations. The use of sophisticated econometric techniques as part of the final evaluation means we have a high degree of confidence in the findings listed below.

From difference-in-difference modelling we know that (SQW, 2019 B) over half of the beneficiary group indicated that they had introduced a new or improved process as a result of the project supported by Smart. This was significantly higher than the proportion of the non-beneficiary group that had progressed their R&D project without Smart.

Survey-based difference-in-difference analysis found negative effects on turnover overall. However, quasi-experimental comparisons of beneficiaries and unsuccessful applicants on the basis of secondary data showed that there were statistically significant positive effects on turnover for certain sub-groups of the beneficiaries[89] (SQW, 2019 B).

Difference-in-difference analysis of secondary data sources revealed a positive effect of the award on employment, with an increase in 0.6 employees per beneficiary, but at a weak level of significance (SQW, 2019 B).

[89] For grant recipients from 2013 and Development of Prototype awardees.

Impact additionality

To assess the outcome/output additionality of the Smart programme, we rely exclusively on the final evaluation report (SQW, 2019 B) as this provides the most up-to-date evidence source and covers all areas assessed by previous evaluations.

We can gross up the findings from the self-reported beneficiary survey to the beneficiary population (including an adjustment for optimism bias to account for the uncertainty of future effects) to explore impact additionality. This relies on self-reported additionality rather than econometric analysis and therefore the results should be treated with some caution. The survey responses suggest that approximately 650 net additional jobs were created by the Smart awards. This is in turn associated with a net GVA impact of approximately £32.5 million by early 2018 (SQW, 2019 B).

4.2.2 Catalyst

To date three evaluation reports relate directly to the Catalyst programme:

- Biomedical Catalyst Evaluation: Process Evaluation and Baseline Impact Evaluation (Ipsos MORI, 2016 B). The methodology used in this study is centred around an overarching evaluation framework. This sets out a theoretical outline for the impact and process evaluations and identifies preferred options for the impact evaluation. Following the development of the framework, we can draw on direct effects evidence from a number of different specific methods which were used in tandem:
  - analysis of management information and secondary datasets;
  - stakeholder consultation;
  - survey of successful applicants and unsuccessful applicants to serve as a counterfactual;
  - case studies across each type of grant awarded; and
  - data linking of applicants to sources of secondary data such as the Business Structure Database.

  The direct effects evidence arises primarily from the survey results. The authors made extensive use of econometric techniques when comparing between successful and unsuccessful applicants to create a credible counterfactual. These techniques include propensity score matching, to balance characteristics of successful and unsuccessful applicants, and regression discontinuity design, to compare applicants who had narrowly missed out on funding to those who had received funding but were close to missing out. The sample consisted of 207 applicants, which represented a 73% response rate.
- Process Evaluation of Catalyst Programmes: Interim Progress Report (SQW, 2017 C). SQW carried out a qualitative process evaluation of the other Catalyst programmes (Agri-tech Catalyst, Energy Catalyst and Industrial Biotechnology Catalyst). This is an interim findings report. Stakeholders consulted include beneficiary firms, management and delivery staff, monitoring officers and the

bid review panel. The evaluation provides a rich source of qualitative data but is not intended to generate quantified direct impacts.

- Process Evaluation of the Catalyst Programmes: A Final Report to IUK (SQW, 2019 D). The SQW finalised process evaluation of the Catalyst programme is based on:
  - a desk review of data and documentation available for the Catalysts; and
  - an extensive consultation with 23 management and delivery staff and strategic leads, 10 panel assessors and monitoring officers, beneficiaries (60 via telephone, plus in-depth case studies with leads and collaborators for 15 projects), 35 organisations who had submitted an unsuccessful application to the Catalyst programme, and 14 external stakeholders across the sectors.

  This evaluation provides a rich source of qualitative data but is not intended to generate quantified direct impacts.

Input additionality

We can see from a propensity score matching analysis that the provision of grant funding via the Biomedical Catalyst has had a significant impact on overall investment in the projects and that the resources invested in the projects are additional. Specifically, we know that successful applicants saw their total funding rise by around 53% relative to 36% amongst unsuccessful applicants (Ipsos MORI, 2016 B). We can have a high level of confidence in these findings due to the econometric techniques used.

However, it is important to note that the Biomedical Catalyst has had a negative impact overall on the levels of subsequent external funding raised by academics following the notification of the award. This is due to Medical Research Council funding rules preventing 'double funding' of a project (Ipsos MORI, 2016 B).

This robust quantitative analysis is supported by qualitative findings. A process evaluation of the Catalyst programme showed that participants in the Energy Catalyst reported that the programme had helped create a large portfolio of innovative projects which potential investors can be directed towards. The interviewees felt that this in turn had helped projects to access more private funding than they would have been able to otherwise (SQW, 2017 B, 2017 C). The final process evaluation of the Catalyst programme indicated that 20 of the 60 beneficiaries interviewed had leveraged further private investment following participation in the Catalyst (SQW, 2019 D).

Attitudinal additionality

Qualitative engagement with participants provides us with an indication that the Agri-tech Catalyst has improved industry innovation appetite and led to improvements in participants' capability and confidence to apply for R&D funding (SQW, 2017 C).

Similarly, a separate qualitative engagement exercise with Catalyst participants allows us to conclude that participants were more open to collaboration following their involvement with the Catalyst (SQW, 2019 D).

We cannot be as confident in these attitudinal additionality results (relative to other direct impact findings which relate to the Catalyst programme) as they rely entirely on self-reported information from beneficiary firms and no comparison group was used.

Behavioural additionality

The propensity score matching and regression analyses of both successful and unsuccessful applicants revealed that the Biomedical Catalyst programme has had a significant and substantial impact on the acceleration of funded projects. On average, we know that Catalyst projects progressed almost one Technology Readiness Level (TRL) further than they would have done otherwise (Ipsos MORI, 2016 B). We can have a high level of confidence in these findings due to the econometric techniques used.

This robust quantitative analysis is supported by qualitative findings. Self-reported data shows that 42% of beneficiaries did not believe they would have progressed their projects at all without the Catalyst. Only 11% of the projects in the control group had progressed as planned (SQW, 2019 D).

Outcome/output additionality

The propensity score matching and regression analysis showed no significant differences between successful Biomedical Catalyst applicants and unsuccessful applicants in terms of total R&D spending or R&D employment (Ipsos MORI, 2016 B).

The turnover of successful firms rose more rapidly than that of unsuccessful applicants. However, it is difficult to link this result directly to Biomedical Catalyst funding as so few had brought a product to market (Ipsos MORI, 2016 B).

We do see that higher proportions of unsuccessful applicants produced research outputs. However, as the authors acknowledge, this is not necessarily a negative finding at this stage as beneficiaries may be delaying the preparation of articles to seek publication in higher-status journals (Ipsos MORI, 2016 B).

We can have a high level of confidence in these findings due to the econometric techniques used.

Impact additionality

This area of direct impact has not yet been assessed for this programme. This will be assessed in future evaluations.

4.2.3 ICURe

To date evidence relating to the direct impact of the ICURe programme is based on ICURe Evaluation: Final Evaluation Report (Ipsos MORI, 2018 B). A mixed-methods approach has been employed, which allows us to be confident in the conclusions. Specifically, the findings we report below are based on a combination case studies, analysis of monitoring data, stakeholder consultations and applicant surveys to assess programme impacts.

Direct impacts are primarily based on an analysis of survey results. The survey sample consisted of 222 respondents (162 participants and 59 non-participants). Econometric difference-in-difference analysis allowed us to explore the causal effects of the programme in a robust manner. This adequately controls for observed differences between groups and implies that we can have a high level of confidence in the findings. However, if participating and non-participating teams differ in unobserved ways the econometric analysis may be biased. Also, the results were not able to account for participation in other complementary programmes that may have contributed to the results observed.

Input additionality

Econometric difference-in-difference analysis shows that participating survey respondents were significantly more likely than non-participants to have obtained private research contracts (33% versus 12%) (Ipsos MORI, 2018 B).

Attitudinal additionality

The assessment of attitudinal additionality is based on case study findings rather than quantitative analysis. As such it will not be as robust and should be treated as indicative rather than definitive. Qualitative evidence from the case studies provides us with an indication that the training sessions which formed a part of the ICURe programme improved researchers' confidence and developed their commercial awareness and interpersonal skills (Ipsos MORI, 2018 B).

Behavioural additionality

The robust econometric modelling allows us to conclude with a high level of confidence that participating teams progressed further on a business readiness index than they would have done without the ICURe programme. Participants progressed most rapidly in establishing a cost structure, establishing customer relationships and identification of channels to market.

We also know from this analysis that ICURe had a significant impact on the likelihood of teams pursuing and achieving a commercialisation outcome. Specifically, the likelihood a commercialisation outcome was achieved increased from 8% to 40%.

As described above the techniques applied to determine these effects are highly robust. Our confidence in these findings is enhanced further as a result of a parallel analysis which was carried out to examine spin-out and licensing outcomes at an institutional level using secondary data. We see that in keeping with the survey analysis, four of the five ICURe institutions outperformed their synthetic counterpart in terms of the number of spin-outs established (Ipsos MORI, 2018 B).

Outcome/output additionality

Participants and non-participants were also compared in terms of employment growth using robust difference-in-difference analysis (Ipsos MORI, 2018 B). From this comparison we can conclude that spin-outs established by teams participating in ICURe grew more rapidly than those established by non-participants.

On average, spin-outs established by participating teams employed the equivalent of three full-time workers and had an average turnover of £86,000. Average employment was only one full-time worker in spin-outs established by teams that had not participated in ICURe, and none were generating revenues yet (Ipsos MORI, 2018 B).

Impact additionality

We can assess the market value of the additional spin-outs attributable to ICURe. At the time of evaluation this was valued at £35 million. However, this finding is based solely on the ICURe pilot and the total benefit may therefore evolve in the longer term.

If the net present value of this benefit is compared to the costs associated with delivering the programme (not including the additional costs incurred by universities and the private sector), we conclude that the ICURe pilot had an approximate benefit to cost ratio of £3.94 per £1 of public expenditure (Ipsos MORI, 2018 B).

4.2.4 CR&D

To date, seven evaluation reports relate to sub-programmes within the CR&D programme:

- Strategic Investments in Low Impact Building: Impact Evaluation (Ipsos MORI, 2017 A). This evaluation consists of an analysis of management information, an applicant survey and a data-linking exercise to facilitate analysis of the impact of the programme on employment/turnover.

  From the survey, we can explore quantitative estimates of the technological, commercial and economic impacts arising from projects that sought Low Impact Building (LIB) funding. 156 interviews were carried out with successful applicants and 141 interviews with unsuccessful applicants. Survey data was subject to detailed econometric modelling. Specifically, difference-in-difference modelling was used to provide a quasi-experimental indication of programme impact. Relevant baseline differences and key characteristics such as R&D capacity, organisation size, project progress and the project quality are controlled for in each regression (both ordinary least squares (OLS) and negative binomial regression models were used). Regression discontinuity techniques were also used where appropriate. Overall, this study makes use of statistical techniques to ensure that the successful and unsuccessful groups were as similar as possible so that a fair comparison can be made. As such, we can have a very high degree of confidence in the findings.

- Strategic Investments in Sustainable Agriculture and Food Evaluation (Ipsos MORI, 2017 B). This evaluation relies on a context review, analysis of management information, stakeholder consultations, an applicant survey, case studies and linking of data on beneficiary firms to administrative data sources to estimate programme impact.

  The survey results provide us with quantitative estimates of technological, commercial and economic impacts of the projects funded. Unsuccessful applicants served as a counterfactual. The survey sample size was 212 successful applicants and 84 unsuccessful applicants. Again, difference-in-difference models were used to provide a quasi-experimental indication of programme impact. Both OLS and negative binomial regression models were estimated. These models accounted for unobservable differences between successful and unsuccessful firms by including the score awarded as a control variable. Regression discontinuity techniques were also used where appropriate. Overall, this study makes use of statistical techniques to ensure that the successful and unsuccessful groups are as similar as possible so that a fair comparison can be made. As such, we can have a very high degree of confidence in the findings.

- The Low Carbon Vehicles Innovation Platform: An Impact Review (IUK, 2015). Direct impact findings related to the Low Carbon Vehicles Innovation Platform are based on a survey IUK carried out with successful applicants. The authors do attempt to control for deadweight, displacement and leakages. However, no control group of unsuccessful applicants was sampled. This limits the robustness of the findings and therefore we treat the results as indicative rather than causal.

- TSB Feasibility Studies Programme: Evaluation Findings (WECD, 2013). This study focuses on 325 projects funded under the programme and completed in 2010/11. The specific work undertaken included a desk-based review of background data and information and survey of participants in the 2010/11 Feasibility Studies Programme (FSP) including non-winners.

  The survey was carried out to establish benefits generated, emerging impact and future plans of applicants. It featured a sample of 228 winners and 212 non-winners. Questions in the survey asked whether benefits would have materialised with FSP support. Descriptive analyses of the survey results were carried out alongside econometric analyses, which allows us to robustly assess direct impacts. The general econometric approach involved regressing R&D intensity (either R&D spending per employee or the proportion of total employees that are involved in R&D) on vector of variables including sector, firm characteristics and use of funding. The authors accounted for potential selection bias by including a selection equation as part of the econometric models. Overall, this study makes use of statistical techniques to ensure comparability between successful and unsuccessful groups. As such, we can have a reasonably high degree of confidence in the findings.

- Advanced Propulsion Centre: Impact and Economic Evaluation Scoping (Ipsos MORI, 2016 A). This report sets out the results of an evaluation scoping study designed to establish an evaluation framework and methodology for assessing the causal effects of the Advanced Propulsion Centre (APC). This report does not present any evidence on direct impacts. The authors set out datasets that could be used in a future evaluation, such as monitoring data, patent data, vehicle production and sales data, and government datasets. The report suggests that primary research with applicants should also be carried out. The overall approach suggested will lead to a very robust evaluation. Specifically, unsuccessful applicants are put forward as the preferred counterfactual. Also, econometric techniques, such as panel regression models and matching methods, are outlined.

- Advanced Propulsion Centre: External Process Evaluation (Ipsos MORI, 2018 A). The aim of this evaluation of the APC is to provide early evidence on what works, the emerging benefits of the programme and lessons for delivery and implementation. The evaluation involved the collection of IUK monitoring records, interviews with key stakeholders of the programme and detailed case studies of ten projects receiving public support through the APC. Direct impact results are based on this qualitative analysis, which explicitly focused on additionality, but no counterfactual is used. Therefore, we cannot have the same level of confidence in the results as we would in other studies considered as part of the evidence synthesis. The final economic evaluation will provide more robust direct impact evidence.

- The Aerospace Technology Institute: Scoping Study to Establish Baselines, Monitoring Systems and Evaluation Methodologies (SQW, 2016 B). This scoping study proposes a framework which could be implemented to evaluate the impact of funding awarded via the IUK/BEIS/ATI sub-programme which is a form of CR&D. The recommended methodology combined top-down approaches (use of secondary data from a variety of sources to track relevant indicators for the UK aerospace sector as a whole) with bottom-up approaches (collection and analysis of data on individual projects co-funded by the ATI, so as to assess their respective outputs and impacts). Sophisticated econometric matching methods such as difference-in-difference analysis are suggested to test the extent to which observed differences were caused by the programme. The final economic evaluation will provide highly robust direct impact evidence.

  Evaluation of ATI Aerospace R&D Programme. Process and Implementation Review (Ipsos MORI, 2017 C). This study seeks to understand the efficiency of the IUK/BEIS/ATI sub-programme and gain an insight into barriers to the programme's implementation. The evaluation involved triangulating evidence from a variety of sources including monitoring information, secondary data, stakeholder interviews, applicant interviews and case studies. This evaluation provides a rich source of qualitative data but is not intended to generate quantified direct impacts.

- Evaluation of the Collaborative Research and Development Programmes: Final Report (PACEC, 2011). This study makes use of mixed methods to assess impact. This allows us to draw on a number of evidence sources including: a desk study focusing on the programme rationale and management information for CR&D, interviews with stakeholders, surveys and interviews with 336 CR&D participants and 205 unsupported bidders. These samples were weighted to ensure representativeness.

The direct impact results were based primarily on the survey results. This consists primarily of a descriptive univariate analysis and cross tabs. The authors calculate the net cumulative effect of the programme by accounting for deadweight and displacement as well as linkages and multipliers. Estimates of direct impact arising from this evaluation, which we report as a control group, is used, and deadweight and displacement are explicitly accounted for. However, the majority of results presented do not include control variables, which would help to increase the reliability of findings further.

Input additionality

We can see from a comparison of successful and unsuccessful applicants to the FSP that there is a positive effect of the scheme on access to finance. One-third of successful applicants reported that they had benefitted from easier access, while none of the non-winners indicated that they had experienced a similar benefit (WECD, 2013). The use of a control group in this case increases the reliability of the findings.

In addition, we are highly confident that both the Strategic Investments in Low Impact Building Fund (Ipsos MORI, 2017 A) and the Strategic Investment in Sustainable Agriculture and Food Fund (Ipsos MORI, 2017 B) were effective in leveraging additional private resources. In each case, robust econometric difference-in-difference analysis reveals that the estimated increase in R&D spending attributable to each programme was over £40 million.

Based on evidence contained in the Evaluation of the Collaborative Research and Development Programme report, we know that 74% of CR&D grant recipients felt that the award helped them to lever additional finance (PACEC, 2011). The lack of a direct comparison to unfunded firms in these cases limits our ability to identify precise causal effects.

The Low Carbon Vehicles Innovation Platform (LCV IP) awarded grants worth £230 million in total. IUK carried out a survey with beneficiary firms and concluded that the projects attracted an extra £424 million in private investment (IUK, 2015). Again, the failure to include any control group in the analysis for this specific case limits our confidence in the precise magnitude of the effects. However, they are very much in keeping with the more robust input additionality effects we describe above.

Attitudinal additionality

Specific case studies carried out as part of the Sustainable Agriculture and Food (SAF) evaluation provide us with a qualitative indication that the funded projects have helped applicants improve skills particularly relating to the sharing of knowledge (Ipsos MORI, 2017 B).

We also know that the majority of successful applicants to the FSP reported that the support had enhanced both their R&D skills and technical understanding (80% and 90% respectively) (WECD, 2013).

Survey evidence allows us to conclude that funded CR&D projects provided access to technical and R&D skills for most participants (67%) (PACEC, 2011).

Also, we can see that the majority of beneficiary firms reported improvements in the technical knowledge and understanding of partners (84%) (PACEC, 2011).

Our confidence in each of the individual attitudinal findings is increased by the consistency of benefits identified across sub-programmes. However, in all three cases no control group was used as a direct point of comparison, and therefore it is difficult to precisely identify additionality.

Behavioural additionality

Difference-in-difference analyses allow us to explore the impact of LIB and SAF on annual R&D spending. In both cases we see statistically significant positive effects. We find that the direct impact on beneficiaries relative to non-beneficiaries is a rise in R&D spending of 43% for LIB and 20% for SAF (Ipsos MORI, 2017 A, 2017 B). Econometric analysis also suggests that the LIB fund has accelerated the progress of supported collaborative R&D projects, moving them forward by 0.6 to 1.2 TRL stages further than they would have achieved otherwise. Likewise, the SAF fund has been critical in enabling successful applicants to progress to more advanced stages of delivery. Only 7% of successful applicants have abandoned their project compared with 53% of unsuccessful applicants. The SAF fund has also enabled beneficiaries to move projects forwards by 0.7 to 2 TRLs further than they would have done otherwise. These findings are highly robust due to the advanced econometric methods used.

Self-reported survey evidence from CR&D beneficiaries provides us with an indication that the majority of partners (70%) would not have proceeded with their project if they had not received a CR&D award (PACEC, 2011). Precise additionality in this case is difficult to assess as an explicit control group comparison was not undertaken on these measures.

Also, we know from case studies carried out as part of a process evaluation of the APC fund that supported projects have made substantial progress in commercialisation. However, evidence is only anecdotal at this stage (Ipsos MORI, 2018 A). We will be able to more conclusively assess behavioural additionality when the final economic evaluation report is completed.

In contrast the behavioural effects of the FSP programme are less clear. Robust multivariate regression analysis allows us to conclude FSP funding did not have a statistically significant positive influence on R&D intensity (WECD, 2013). There were significant impacts on R&D intensity for certain sub-groups of successful applicants such as beneficiaries who were in the Nuclear and Energy sectors. In addition, the less reliable self-reported evidence from the same evaluation tells us that the majority of non-winners (60%) abandoned their project entirely when they did not get FSP funding (WECD, 2013).

Outcome/output additionality

We know from difference-in-difference analysis that SMEs[90] in receipt of LIB funding expanded their R&D employment by an additional 10-14% following the

[90] Rather than large businesses. No equivalent effect was found when large businesses were included in the analysis.

award of funding. This resulted in a total of 263 additional jobs. No equivalent effect was identified for large firms. In terms of overall employment,[91] econometric analysis showed no significant effect of the fund. We also have evidence of a positive significant effect on the turnover of successful LIB applicants relative to unsuccessful firms. Difference-in-difference results suggest that this was equivalent to 25% in each year (Ipsos MORI, 2017 A). The robust methods used to generate these effects allow us to have a high degree of confidence in the findings.

In keeping with the direct impacts of the LIB programme, recipients of SAF funding also increased R&D employment by an additional 10% relative to non-recipients. However, the SAF fund is yet to have a significant effect on sales, employment and turnover of supported businesses (Ipsos MORI, 2017 B). The robust methods used to generate these effects allow us to have a high degree of confidence in the findings.

Econometric analysis carried out as part of the evaluation of the FSP showed little significant impact on business performance indicators of successful applicants such as turnover or profitability. However, self-reported evidence suggests that 53% of winners felt that they would definitely not have been able to achieve the same business performance outcomes without the programme (WECD, 2013). The econometric analysis is likely to be more reliable than the self-reported evidence, which leads us to conclude that no business performance effects materialised in this case at the time of evaluation.

Survey evidence (PACEC, 2011) allows us to conclude that more than half of respondents felt the CR&D programme had enabled or will in the future enable them to enter new markets or increase their market share (53%), employment (56%), turnover (53%) or profits (51%). 42% of respondents thought that the project had created at least one job and 40% felt that it had safeguarded a job. If we gross up these findings to the universe of projects unintended at the time of evaluation, we can conclude that the programme led to 13,350 net jobs, allowing for displacement and linkages (PACEC, 2011). We cannot be certain about the precise degree of additionality in this case as no direct comparison to a control group was used.

One of the case studies carried out as part of a process evaluation of the APC provided evidence that a participant was ready to launch a new product as a result of the fund (Ipsos MORI, 2018 A). This evidence should only be treated as indicative at this stage.

We also know that participants in the LCV IP forecasted a substantial increase in sales and employment attributable to the programme. However, we cannot be completely confident of additionality in this case as no control group was used (IUK, 2015).

Impact additionality

As we noted above, we have reliable evidence based on econometric analysis that both the LIB programme and SAF fund led to additional R&D jobs for certain

[91] Rather than just R&D employment.

recipient firms. The value of these employment increases in GVA terms are £25.7 million and £25 million respectively. In addition, the LIB was found to increase the efficiency of employees this may lead to further GVA gains.

We can draw on survey evidence from organisations who took part in the FSP which shows that over half the beneficiaries reported experiencing an increase in the value of their business as a result of the programme (WECD, 2013). The magnitude of this result should be treated with caution as no direct comparison with unfunded firms was available.

We also know from self-reported survey evidence that 62% of CR&D beneficiaries thought that the project would increase the value of their business. If we value the additional GVA per annum associated with the self-reported increase in jobs created[92] the gross increase is estimated to be £467 million per annum (PACEC, 2011). We cannot be completely confident of additionality in this case as no control group was used.

We can draw on predicted sales and turnover results from surveyed participants in the LCV IP to calculate a return on investment. Depending on the specific assumptions used, the programme is estimated to generate between £8 and £14 for every £1 invested over the next ten years (IUK, 2015). We cannot be completely confident of additionality in this case as no control group was used.

4.2.5 Innovation Loans Pilot

To date evidence relating to the direct impact of the ILP is based on Evaluation of Innovation Loans: Early Interim Report (SQW, 2019 A). The results below are based on analysis of monitoring data, case studies of ten successful applicant businesses and telephone interviews with the remaining 78 unsuccessful applicants. The use of successful and unsuccessful applicants serves as a counterfactual and allows comparison to be drawn across the two groups. However, a full econometric analysis has not yet been carried out as part of this interim report. Therefore, we cannot be confident that all the findings we report below are fully attributable to the ILP. The final report will address this gap.

Input additionality

Four of the ten businesses who served as case studies were more able to access private sector finance after their experience of the ILP. We also know from a survey of unsuccessful firms that only 31% of this group received funding from other sources to finance the activities outlined in their ILP application (SQW, 2019 A). The lack of detailed quantitative analysis and advanced matching techniques means that, as yet, we cannot be completely confident that this differential is purely additional.

Attitudinal additionality

In terms of the impact of the ILP on firms' skills and attitudes, we know from a survey of non-beneficiary firms that going through the process had raised their

[92] The majority of firms reported that no employment effects had materialised by the time the evaluation was carried out.

ability to make the case for investment (37%) and that 24% now had greater confidence in their ability to raise finance in the future as a result of applying for the ILP (SQW, 2019 A). As above, this evidence should be considered indicative at this interim stage.

Behavioural additionality

Six of the ten businesses who served as case studies reported that they would not have been able to access similar finance in the absence of the ILP. None of the ten case study projects would have happened in the same time scale without the programme. We also know that the loan encouraged three businesses to invest more in R&D than they otherwise would have (SQW, 2019 A). As above, this evidence should be considered indicative at this interim stage.

Outcome/output additionality

We can see some emerging evidence of outcome additionality attributable to the ILP. However, these effects were understandably limited as the programme was only at the pilot stage at the time of evaluation.

In case studies of ten firms who have received the loans, all ten stated that they had experienced some benefits as a result of the loan. Specifically, the loan was reported to have created 13 FTE jobs (five in R&D, one temporary research and technology (R&T) job, and seven in marketing and sales), and a further 12-15 jobs were safeguarded.

In seven of the ten cases, the loan was considered to be a critical contributory factor to the benefits experienced to date. Similarly, seven of the ten businesses expected the loan to help them progress their product or service through to commercialisation.

Additionally, we can conclude from self-reported data that the loan directly increased future R&D investment in six cases, estimated to be an investment of around £800,000 investment in total. Estimates from these six businesses interviewed indicate there will be nearly 65 jobs in R&D created in the future as result of the programme.

As the above findings were not derived using econometrics, we should treat them with caution and they may not be purely causal (SQW, 2019 A).

Impact additionality

Given the that the ILP has been established relatively recently, we know that the programme impacts are yet to fully materialise. The interviews therefore focused on future impacts of the loan that beneficiaries expected to materialise. Most beneficiaries reported that effects of the ILP programme were expected to be achieved at a later date (SQW, 2019 A).

Further work on the impact of the ILP will be included in the forthcoming final report.

4.2.6 Investment Accelerator Pilot

To date, evidence relating to the direct impact of the IAP is based on Investment Accelerator Pilot Evaluation: Deliverable 3 Interim Impact Report (SQW, 2019 C). The authors of the IAP pilot evaluation use case studies, analysis of monitoring data, stakeholder interviews to assess programme impacts.

Most of the authors' analysis is based on interviews with the investors and case studies of six of the IAP projects. These case studies included a review of background documentation along with telephone interviews.

There was no counterfactual group identified at this stage. These interim results therefore should be treated with a certain level of caution. More robust evidence will emerge when the final impact report is completed.

Input additionality

Case studies carried out with pilot participants show us that over half of beneficiaries of the IAP secured follow-on finance in the range of £300,000 to £3.2 million as result of the programme.

Additionally, from a survey of beneficiaries we know that 35% of the participants interviewed felt that they had strengthened existing or had developed new relationships with investors (SQW, 2019 C). This evidence should be thought of as indicative rather than causal at this stage as the lack of a control group means that we cannot be fully confident that reported impacts are fully attributable to the ILP. More conclusive evidence will emerge as the evaluation progresses.

Attitudinal additionality

We can also conclude from the self-reported survey that a significant minority (42%) of the beneficiaries felt that they had improved their business management capabilities as a result of the programme, including problem solving, project management and business planning (SQW, 2019 C). The same limitations noted above in relation to robustness also apply here. These will be addressed as part of the final evaluation report.

Behavioural additionality

When questioned on their IP activities, 33% of the IAP beneficiaries reported applying for or securing patents as a result of the programme.

Beneficiaries also reported benefitting from new connections and networks (54%) as a result of the programme and reported improving their understanding/access to market opportunities. Again, no control group was used for this comparison, which limits the robustness of this finding.

Outcome/output additionality

We can see that all 27 businesses consulted reported making progress in moving towards commercialisation as a result of the pilot.

We can see that 63% of the beneficiary businesses had created new employment (between 1-4 jobs each). A similar magnitude of the beneficiaries (72%) self-reported that the IAP had increased their likelihood of exporting.

The self-reported responses of beneficiaries indicated full additionality in 41% of cases (they would not have achieved any outcomes at all without IAP).

In addition, various forms of partial additionality were self-reported by the beneficiaries; 62% stated some or all of the outcomes had been accelerated, 31% stated outcomes would have been on a smaller scale without IAP and lastly 19% stated outcomes would not have been as high quality in the absence of IAP. These groupings were not mutually exclusive.

In contrast, only 4% said outcomes would have been achieved without IAP,[93] indicating little to no deadweight for the programme.

All of these findings should be thought of as indicative rather than causal due to the lack of an identified control group. More robust evidence will emerge in the future when the final evaluation report is completed.

Impact additionality

To date, we do not have evidence of any impact additionality. We would not expect this to have materialised as of yet (SQW, 2019 C). This will be assessed in future evaluations.

[93] Other than softer investor relations outcomes.

5 PROGRAMME LEVEL INDIRECT IMPACTS: RESULTS

5.1 Introduction

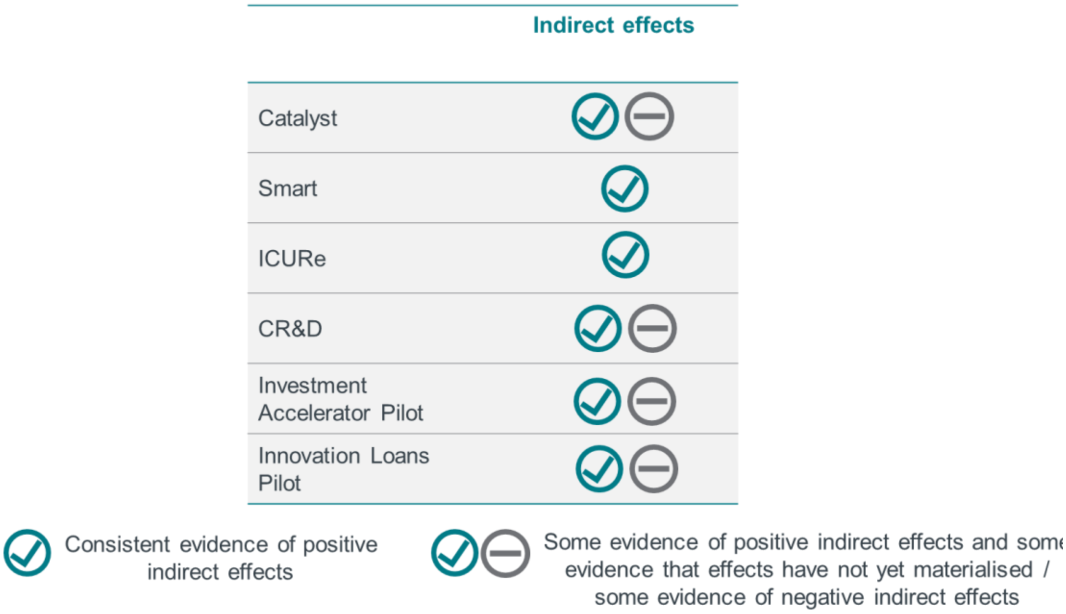
Indirect impacts refer to the effects of the Innovate UK (IUK) scheme on non-beneficiary firms or the wider economy. In this section, we review existing evidence related to spillovers.

5.2 Summary of positive and negative spillovers

In addition to the direct impacts of the IUK scheme, non-beneficiaries may be affected by the scheme via spillover effects. Non-beneficiaries in this context can include customers, suppliers, collaborators and competitors. They may experience positive spillovers, for example, if a beneficiary firm's collaborator gains enhanced knowledge of novel production techniques. Negative spillovers can also occur, for example, if a beneficiary firm's competitors can no longer compete effectively.

On balance, existing evidence from the programme-specific evaluations shows that spillovers observed to date are almost entirely positive, but importantly these impacts tend to be self-reported. Figure 29 summarises the indirect effects associated with each IUK programme. In Chapter 6, we set out how we carried out a robust trade and competition analysis, which will provide quantitative and qualitative evidence on the extent to which the overall scheme has distorted certain markets.

Figure 29 Summary of indirect effects across IUK programmes[94]



*Note: Evidence on the indirect impact of the **Catalyst Programme** is based on: Biomedical Catalyst Evaluation: Process Evaluation and Baseline Impact Evaluation (Ipsos MORI, 2016 B), Process*

[94] Evidence covering the Innovation Loans Pilot scheme did not contain any assessment of indirect effects. As such, it has not been included in this section.

Evaluation of the Catalyst Programmes: Scoping Paper (SQW, 2017 B), Process Evaluation of the Catalyst Programmes: Interim Progress Report (SQW, 2017 C), Process Evaluation of the Catalyst Programmes: A Final Report to Innovate UK (SQW, 2019 D).

*Evidence on the indirect impact of **ICURe** is based on: ICURe Evaluation: Final Evaluation Report (Ipsos MORI, 2018 B).*

*Evidence on the indirect impact of **Smart** grants is based on: Evaluation of Smart: Impact and Process Evaluation (SQW, 2015), Evaluation of Smart: On-going Evaluation – Year 1 Report (SQW, 2016 A), Evaluation of Smart: On-going Evaluation – Year 2 Report (SQW, 2017 A), Evaluation of Smart: On-going Evaluation – Final Report (SQW, 2019 B).*

*Evidence on the indirect impact of the **CR&D programme** is based on: Evaluation of the Collaborative Research and Development Programmes: Final Report (PACEC, 2011), Strategic Investments in Low Impact Building: Impact Evaluation (Ipsos MORI, 2017 A), Strategic Investments in Sustainable Agriculture and Food Evaluation (Ipsos MORI, 2017 B), The Low Carbon Vehicles Innovation Platform: An Impact Review (IUK, 2015), Advanced Propulsion Centre: Impact and Economic Evaluation Scoping (Ipsos MORI, 2016 A), The Aerospace Technology Institute: Scoping Study to Establish Baselines, Monitoring Systems and Evaluation Methodologies (SQW, 2016 B), Evaluation of ATI Aerospace R&D Programme. Process and Implementation Review (Ipsos MORI, 2017 C).*

*Evidence on the indirect impact of the **Innovation Loans** Pilot is based on: Evaluation of Innovation Loans: Early Interim Report (SQW, 2019 A).*

*Evidence on the indirect impact of the **Investment Accelerator** Pilot is based on: Investment Accelerator Pilot Evaluation: Deliverable 3 Interim Impact Report (SQW, 2019 C).*

Our review of available evidence revealed that certain programmes within the scheme were associated with consistently positive indirect impacts. In these cases, we filled the relevant cell with a tick symbol.

In other cases, our review of existing evaluation reports indicated that a programme had some positive indirect effects but there was also evidence of either a lack of positive indirect impacts or negative indirect impacts. When that occurred, we filled the relevant cell with a tick and a dash to represent the mixture of existing evidence.

Importantly there was no cell across any of the programmes and areas of interest where no positive indirect effects could be seen to date.

5.2.1 Existing evidence suggests positive spillovers are more prevalent than negative spillovers

Positive spillover effects were commonly identified across the majority of IUK programmes within the aid schemes that have been evaluated to date. The EC's Common Methodology for State Aid Evaluation refers to spillovers as a potential positive indirect effect of an aid scheme (EC, 2014 A).[95]

97% of Smart award recipients believed the programme led to positive effects on customers, suppliers, competitors or collaborators (SQW, 2019 B). However, the authors note that there is currently limited compelling evidence that spillovers have so far been realised for external economic agents. In some cases, different spillovers are reported and, in other cases, no spillovers had been experienced by the indirect beneficiary. This could be because formal mechanisms are not yet in place to facilitate these spillovers (SQW, 2019 B). When these spillovers arise,

[95] See p. 36, https://ec.europa.eu/competition/state_aid/modernisation/state_aid_evaluation_methodology_en.pdf

there are likely to be some outside of the market, e.g. health or environment, benefits (SQW, 2019 B).

Suppliers were another group commonly identified as receiving a positive indirect impact. In the ICURe scheme, unsuccessful applicants found the application process and associated signposting helpful (Ipsos MORI, 2018 B). In addition, Catalyst participants reported that collaborations increased after the programme (SQW, 2017 B). In the final process evaluation of the Catalyst programme (SQW, 2019 D), qualitative evidence supports both positive spillovers, in terms of additional follow-on collaborative R&D, and strengthened supply chains. For the early-stage projects (the Investment Accelerator Pilot (IAP) and Innovation Loans Pilot (ILP)), little information was included about the indirect impacts.

While it was stated that spillovers of the IAP, particularly in the supply chain, would be more likely to materialise later in time, no statistical evidence was yet provided. A number of self-reported figures in the report did relate to spillovers, however. For example, beneficiaries reported benefitting from new connections and networks (54%) and reported improving their understanding/access to market opportunities as a result of the programme (36%) (SQW, 2019 A).

Similarly, spillovers are yet to be studied in detail for the Innovation Loans Pilot. The limited spillovers reported also only pertained to the non-beneficiary group. 37% of the non-beneficiaries considered that going through the application process had raised their ability to make the case for investment, and 24% now had greater confidence in their ability to raise finance in the future as a result of applying for the ILP (SQW, 2019 C).

Very few negative spillovers were reported by beneficiaries. In the CR&D evaluation, 48% of recipients believed that customers would be positively impacted. However, 5% of the same group reported that their project had had negative indirect effects on customers, suppliers or competitors (PACEC, 2011).

5.2.2 Spillovers can be grouped into distinct categories

The Smart evaluation (SQW, 2015) provides a categorisation of indirect effects. This framework can be applied more widely across the IUK aid scheme. Spillovers are divided into four groups:

- **Knowledge** developed by beneficiary firms can be shared with non-beneficiaries, for example through collaborations and demonstrations.
- **Market** spillovers occur through the development of new products and processes. These can lower prices, which benefit other market participants.
- **Network** interdependencies between technologies mean that positive effects experienced by programme participants can also benefit non-participants. An example of this is indirect effects for suppliers, who may see additional routes to market.
- **R&D&I capacity** is the ability of firms to assimilate new ideas. This can lead to non-participant firms expanding their ability to develop new products as a result of R&D&I carried out by participant firms.

Positive spillovers identified in other evaluations can generally be classified using the same framework. For example, more than two-thirds of CR&D beneficiaries thought that the outputs of their project would be widely disseminated (PACEC, 2011). This could potentially lead to a knowledge spillover.

5.2.3 To date, spillovers have been assessed using a variety of research methods

Evaluations used different methods to explore indirect effects. In some cases, surveys were used to ask beneficiary firms about who they thought would benefit and what these benefits may be. Several evaluations also relied on in-depth case studies of beneficiaries, self-reported figures and anecdotal evidence to provide more detail on potential indirect effects.

The lack of negative spillovers may be partially related to the fact that most evidence comes from beneficiary firms who may not be best placed to accurately identify negative spillovers. However, around one-third of unsuccessful applicants to the Innovation Loans Pilot stated positive indirect effects as a result of their application for the loan (SQW, 2019 C).

Encouragingly, the Year 2 Smart report (SQW, 2017 A) did undertake analysis of five pairs of direct and indirect beneficiaries (which had been initially identified by beneficiaries) to test the consistency in the nature of 'observed' and 'experienced' spillovers. The authors found that, in some cases, both the beneficiary and the indirect beneficiary perceived the same indirect effects. However, in other cases the direct beneficiary overestimated the magnitude of positive spillovers relative to the reported experience of the indirect beneficiary.

As we described above, analysis of the direct impacts of the IUK scheme has involved extensive use of advanced quantitative methods. Similar techniques have not been commonly applied in the context of indirect effects to date. The published evaluation plan does note that qualitative evidence will be used to help evaluate the indirect impact of the scheme (EC, 2015 A).[96] Encouragingly, the Advanced Propulsion Centre scoping study proposed examining indirect effects using an international comparative study (Ipsos MORI, 2016 A). The full evaluation has not yet been published. In addition, we have used a combination of quantitative and qualitative analysis to explore scheme level indirect effects on trade and competition. The detailed methodology underpinning this analysis and the associated results are set out in the following chapters.

[96] See p 4, https://ec.europa.eu/competition/state_aid/cases/256732/256732_1703219_80_2.pdf

6 INDIRECT IMPACTS ON COMPETITION: IDENTIFICATION OF THE RELEVANT MARKETS

6.1 Introduction

As we showed in Chapter 2, the Innovate UK (IUK) aid scheme distributed over 9,000 grants to private sector businesses between 2014/15 and 2017/18. Since these businesses operate across a wide range of different markets, it is not practical or cost effective to analyse in detail every market that has received in-scope funding. Instead, we adopt a proportionate approach, selecting four representative markets and evaluating the competition and trade impacts of aid on these markets in detail.

6.2 Market definition

6.2.1 Merger assessment approach

Under European Commission (EC) competition law, appropriate product and geographic markets are defined on the basis of demand-side and supply-side substitutability, with two products included within the same market if they are close substitutes on the demand side and/or supply side (EC, 1997).[97]

Market definition exercises undertaken, for example for the purposes of EC merger assessments, can be extremely lengthy and costly processes. To determine demand-side and supply-side substitutability, these exercises often involve extensive testing of consumer and producer responses to price changes and use confidential business data that the EC has the power to request.

A precise market definition exercise can be critical in determining whether a merger should be allowed to proceed as it is used to identify the competitive constraints placed by others within the same market. However, in this evaluation, which seeks to select multiple markets receiving the highest proportions of aid and understand what impact, if any, aid has had on competition and trade, the same level of precision is likely to be unnecessary. The types of companies and activities that have received funding from IUK can be identified without a complex analysis of demand substitutability patterns across many firms. Such analysis would also be disproportionately costly given that, to assess the impact of aid on competition and trade, our evaluation would not rely on specific market share thresholds.

An assessment of a similar depth is not required in this evaluation. However, it is important to be aware of the high-level areas in which beneficiary firms are operating as that could influence the likelihood of the aid crowding out other R&D. Our market assessment approach is described below.

[97] See p 6, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31997Y1209(01)&from=EN

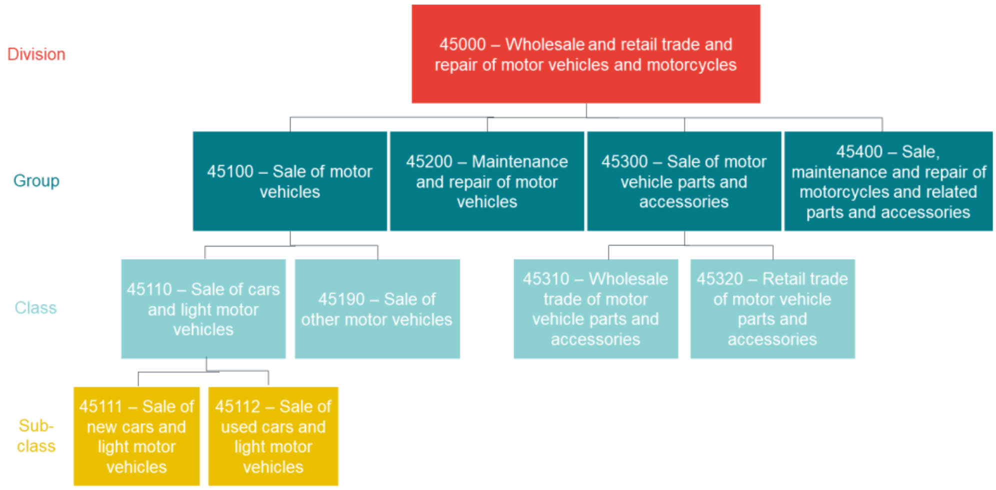
6.2.2 SIC code approach

To select markets for this evaluation we want to ensure that consistent data is available across multiple markets. We therefore use the market definitions contained within administrative datasets. Specifically, we use the UK Standard Industrial Classification (SIC) of economic activities system[98] to classify businesses receiving aid into granular sectors which proxy to economic markets.

The SIC system uses five-digit codes to identify particular industries and place them in a hierarchical structure. The SIC classification is equivalent to the Statistical Classification of Economic Activities in the European Community (NACE) classification used across the EC.

The SIC system is divided into 21 sections, each denoted by a single letter from A to U (for example, Section C covers all manufacturing activity). These sections are then broken down into divisions (two digits). The divisions are then further broken down into groups (three digits), classes (four digits) and, in several cases, sub-classes (five digits). We illustrate one specific example below in Figure 30.

Figure 30 SIC code example



Source: https://www.gov.uk/government/publications/standard-industrial-classification-of-economic-activities-sic

In total, there are 21 sections, 88 divisions, 272 groups, 615 classes and 191 sub-classes (Companies House, 2018). A single SIC code is assigned to each entity included within statistical business registers. This code reflects the entity's principal economic activity.[99] When focusing at the most granular level possible, SIC codes allow the UK economy to be divided into 730 mutually exclusive and exhaustive industries, which we refer to as five-digit SIC codes (technically these 730 SIC codes include some sub-classes, e.g. *45111 – Sale of new cars and light motor vehicles, classes*; *45190 – Sale of other motor vehicles, and groups*; *45200 – Maintenance and repair of motor vehicles*).

[98] Further detail available here: https://www.gov.uk/government/publications/standard-industrial-classification-of-economic-activities-sic

[99] The principal activity is the activity which contributes most to the value added of the unit. In the simple case where a unit performs only one economic activity, the principal activity of that unit is determined by the category of SIC which describes that activity. If the unit performs several economic activities, the principal activity is determined on the basis of the value added associated to each activity.

SIC codes are commonly used in academic publications to define markets. For example, recent articles use SIC codes and their international equivalents to investigate market concentration in the USA, EU and UK.[100]

There are some limitations in using SIC codes to define markets. First, some SIC codes may not be good proxies for the economic markets defined in merger assessments. For example, some SIC codes may contain hundreds of firms producing products that are not necessarily close substitutes. In this case a given SIC code may contain many different economic markets. Some emerging markets supported by IUK may also not yet be well captured by the SIC system, particularly given that the most recent update of the SIC system was completed in 2007. Second, the data available at a SIC code level only covers the UK but competition in some markets may take place at a local , EU or global level. Third, large businesses may operate across multiple five-digit SIC codes but are assigned a single code which reflects the entity's principal economic activity. This adds noise when we attribute economic activity and IUK aid to specific SIC codes.

We take these limitations into account when conducting our competition and trade analysis. In particular, we focus on SIC codes more likely to proxy economic markets (i.e. those with a relatively small number of organisations that perform a similar set of activities and face similar competitive conditions). Where our chosen SIC codes are less appropriate for understanding the nature of competition, we use industry reports and stakeholder interviews to provide a more holistic view of IUK funding impacts on competition and trade. We are conservative when assessing concentration levels, so even if economic activity is not particularly concentrated at a SIC code level, we will not rule out distortions and will acknowledge the possibility that there may be concentrated clusters within the SIC code.

6.3 Approach for market selection

Our approach to selecting markets for further competition and trade analysis is summarised in Section 3.4. Within the SIC code approach to market definition, three factors inform our choice of markets for further analysis:

- **Ratio of IUK funding to market size**. SIC codes might be expected to be more likely to have been affected by IUK funding if they have received a high relative amount of funding compared to the size of the market as defined by turnover.[101] Relatedly, in several cases IUK identifies high-priority sectors/challenges where their input can make the most difference (see Section 2.2 for further details).[102] It makes sense for us to focus on SIC codes which are related to these high-priority sectors/challenges as one might expect aid to have a more significant impact in these SIC codes.

[100] See for example Valletti et al. (2017), Grullon, et al. (2017), Bell and Tomlinson (2018), The Economist (2016), Resolution Foundation (2018).

[101] Ideally, we would also like to assess the ratio of IUK funding relative to market size, defined according to total R&D investment. This is not possible for each SIC code due to a lack of available data. We examined this ratio wherever possible as part of our assessment of shortlisted markets.

[102] These high priority sectors/challenges often align with UK government priorities, such as those set out in the UK's Industrial Strategy.

- **Number of beneficiary firms**. SIC codes in which larger shares of beneficiary firms are located are more likely to be representative of the overall aid scheme. In addition, for confidentiality reasons, any quantitative analysis we do based on the Business Structure Database must include a sample of at least ten firms. We thus focus on SIC codes with at least ten funded firms in the SIC code.
- **Extent to which a given SIC code is a good proxy for an economic market**. Given the limitations of using SIC codes to define markets, we would prefer to choose SIC codes that do a good job of approximating economic markets. This is more likely to be the case if SIC codes isolate a relatively small number of firms that perform a similar set of activities and face similar competitive conditions.

6.3.1 Ratio of funding to market size

To calculate Innovate funding and total market size for each SIC code, we link the IUK funding data, described in our Description of the Aid Scheme chapter, to an administrative micro level dataset called the Business Structure Database (BSD).[103]

The Business Structure Database

This BSD (UK Data Archive, 2006) is produced by taking a 'snapshot' every March of the Interdepartmental Business Register (IDBR). It contains information on every business in the UK that is either VAT registered (i.e. it generates turnover above the UK's VAT threshold)[104] or has at least one employee earning above the PAYE threshold for income tax. It sources data from both HMRC (VAT registration and PAYE administrative data) and Office for National Statistics (ONS) business surveys.

The unit of observation in the BSD is an enterprise, defined as '…the smallest combination of legal units that is an organisational unit producing goods or services, which benefits from a certain degree of autonomy in decision-making, especially for the allocation of its current resources'.[105] [106]

The BSD includes measures of employment and turnover for each business, and various demographic variables recording the nature of the business including:

- postcode (and mappings to standard UK geographies such as region and constituency);
- sector (five-digit SIC code);

[103] More specifically, given the confidential nature of the data contained in the Business Structure Database, the ONS linked the IUK funding data and the Business Structure Database on our behalf.

[104] As of April 2019 the threshold is £85,000 (https://www.gov.uk/government/publications/vat-thresholds-remain-unchanged/vat-maintain-thresholds-for-2-years-from-1-april-2020).

[105] https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Enterprise_-_SBS

[106] An enterprise may be made up of multiple sites (called 'local units') – for example, different offices or stores. Or an enterprise may be a single local unit. An enterprise may also be part of a larger 'enterprise group', which is '...an association of enterprises bound together by legal and/or financial links and controlled by the group head. The group head is a parent legal unit which is not controlled either directly or indirectly by any other legal unit'. See https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Enterprise_group.

- legal status (whether a company, sole trader, partnership, etc.);
- when the business was 'born'; and
- indicators of whether the business is foreign-owned.

The BSD does not include information on businesses which are not registered for VAT or PAYE. The UK government estimates that there are around 3 million unregistered businesses[107] but these businesses account for less than 3% of turnover.[108]

As the BSD draws on various sources of data, each of which has lags in when businesses have to report against them, there is no clear indicator of the precise fiscal or calendar year to which the data recorded in the BSD actually refers. The best estimate is that the data in the 2018 BSD publication best captures employment and turnover for the 2016/17 financial year.[109] We therefore refer to the analysis in this document as '2016/17 data'. In practice, some of the measures of employment and turnover may be slightly earlier or slightly later than this.

Data linking

Given the confidential nature of the data contained in the BSD, the ONS linked the IUK funding data and the BSD on our behalf using Company Registration Numbers. We were then able to analyse an anonymised version of the linked dataset in a secure location within the ONS offices in Pimlico, London.

Calculations

For each SIC code with at least ten funded firms, we calculate market size, (measured using the turnover variable in the BSD) and in-scope IUK aid using data from 2015/16, the first full financial year of the aid scheme.[110] The analysis focuses exclusively on the turnover and funding received by private sector businesses[111] because competition and trade impacts are more likely to result from funding distributed to private sector firms and because SIC codes may give a misleading view of the activities of non-private sector organisations (e.g. a university may

107 UK government estimates by the Department for Business, Energy and Industrial Strategy (BEIS) from the Business Population Estimates suggest that around 2.65 million businesses are captured in the BSD but that there are in total 5.67 million private sector businesses in the UK once unregistered sole proprietorships or partnerships are included.

108 In 2018 they were estimated by the ONS to employ around 3.36 million people as sole proprietors or partners (12.4% of total employment) and have turnover of around £110.6 billion (2.9% of total turnover).

109 Similarly, the 2017 BSD publication best captures employment and turnover for the 2015/16 financial year. The 2016 BSD publication best captures employment and turnover for the 2014/15 financial year etc.

110 As a robustness check, we also calculated funding and turnover for the period 2013/14 to 2015/16. Since funding is distributed over multiple years for most projects, the results are not sensitive to the specific year chosen.

111 Specifically, enterprises with a legal status defined as public sector, central government, local authority or non-profits are excluded from the analysis. We also exclude private enterprises with SIC classification of 84 (*Public administration and defence*), 97 or 98 (*Activities of households as employers*) or 99 (*Activities of extraterritorial organisations and bodies*). This is consistent with the definition used in the BEIS Business Population Estimates publication. It may differ from the self-reported classification of private sector businesses used in our analysis of IUK funding data in the Description of the Aid Scheme chapter, but we expect any differences to be small.

receive IUK aid to conduct research into biotechnology, but the university SIC code is likely to be *82210 – Colleges, universities, and professional schools*).[112]

Results

Figure 31 lists the 49 SIC code sub-classes that contain at least 10 businesses receiving Innovate UK funding in 2015/16,[113] which is 7% of the 730 five-digit SIC codes. Looking over a longer period, 2014/15 to 2016/17, the number of SIC codes where IUK funded at least one firm is very large, 405, which is 55% of SIC codes.

As expected, Innovate UK funding goes to businesses in a wide variety of SIC codes from *Manufacture of prepared feeds for farm animals* to *Business and domestic software development*. Manufacturing SIC codes feature prominently with 17 out of the 49 SIC codes being manufacturing-based.

In the EC's Common Methodology for State Evaluation (2014, A)[114] sectoral bias is included as a possible result dimension for negative indirect impacts of the aid scheme. This occurs if the aid was predominantly granted to one industry in a multi-sectoral scheme. Clearly this is not the case in relation to the IUK aid as over 400 SIC codes contained recipient firms in a single year.

Figure 31 Five-digit SIC codes where Innovate UK provided funding to at least 10 businesses in 2015/16

SIC code	SIC code
10910 - Manufacture of prepared feeds for farm animals	46900 - Non-specialised wholesale trade
20140 - Manufacture of other organic basic chemicals	58290 - Other software publishing
20590 - Manufacture of other chemical products n.e.c.	61900 - Other telecommunications activities
22290 - Manufacture of other plastic products	62011 - Ready-made interactive leisure and entertainment software development
25610 - Treatment and coating of metals	62012 - Business & domestic software development
25620 - Machining	62020 - IT consultancy activities
26110 - Manufacture of electronic components	62090 - Other IT service activities
26511 - Manufacture of electronic instruments & appliances	63110 - Data processing, hosting and related activities
26600 - Manufacture of irradiation, electromedical & electrotherapeutic equipment	63120 - Web portals
26701 - Manufacture of optical precision instruments	70100 - Activities of head offices
27110 - Manufacture of electric motors, generators and transformers	70229 - Business consultancy activities other than financial management
27900 - Manufacture of other electrical equipment	71111 - Architectural activities

[112] As shown in the Description of Aid Scheme chapter, universities and other non-private sector organisations accounted for 24% of in-scope aid scheme funding distributed by IUK between 2014/15 and 2017/18.

[113] In some cases when a four digit SIC code has not been subdivided these markets are classes rather than sub-classes. In all cases we use the most granular breakdown possible.

[114] See Annex II p. 36

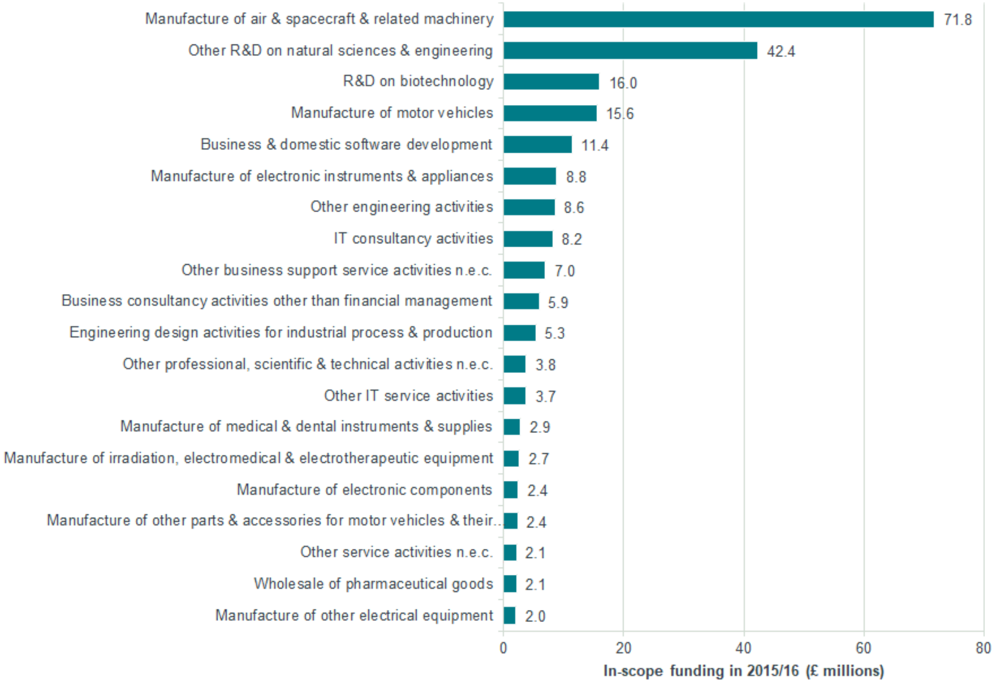
SIC code	SIC code
28290 - Manufacture of other general-purpose machinery n.e.c.	71121 - Engineering design activities for industrial process & production
28990 - Manufacture of other special-purpose machinery n.e.c.	71122 - Engineering related scientific and technical consulting activities
29100 - Manufacture of motor vehicles	71129 - Other engineering activities
29320 - Manufacture of other parts & accessories for motor vehicles & their engines	71200 - Technical testing and analysis
30300 - Manufacture of air & spacecraft & related machinery	72110 - R&D on biotechnology
32500 - Manufacture of medical & dental instruments & supplies	72190 - Other R&D on natural sciences & engineering
32990 - Other manufacturing n.e.c.	74100 - specialised design activities
46210 - Wholesale of grain, unmanufactured tobacco, seeds and animal feeds	74901 - Environmental consulting activities
46310 - Wholesale of fruit and vegetables	74909 - Other professional, scientific & technical activities n.e.c.
46460 - Wholesale of pharmaceutical goods	82990 - Other business support service activities n.e.c.
46520 - Wholesale of electronic and telecommunications equipment and parts	86900 - Other human health activities
46610 - Wholesale of agricultural machinery, equipment and supplies	96090 - Other service activities n.e.c.
46690 - Wholesale of other machinery and equipment	

Source: Frontier analysis of ONS data (Business Structure Database)

Figure 32 ranks the top five-digit SIC codes in terms of absolute Innovate UK aid received in 2015/16. Four five-digit SIC codes received in excess of £15 million over the period in question:

- *Manufacture of air and spacecraft and related machinery*;
- *Other research and experimental development on natural sciences and engineering*;
- *Research and experimental development on biotechnology*; and
- *Manufacture of motor vehicles*.

Figure 32 Top 20 SIC codes (five-digit granularity) receiving Innovate UK funding in absolute terms (2015/16, £ millions)



Source: IUK funding data, Frontier analysis of ONS data (Business Structure Database)

Notes: Excludes SIC codes with fewer than 10 funded firms in 2014/15, 2015/16 or 2016/17

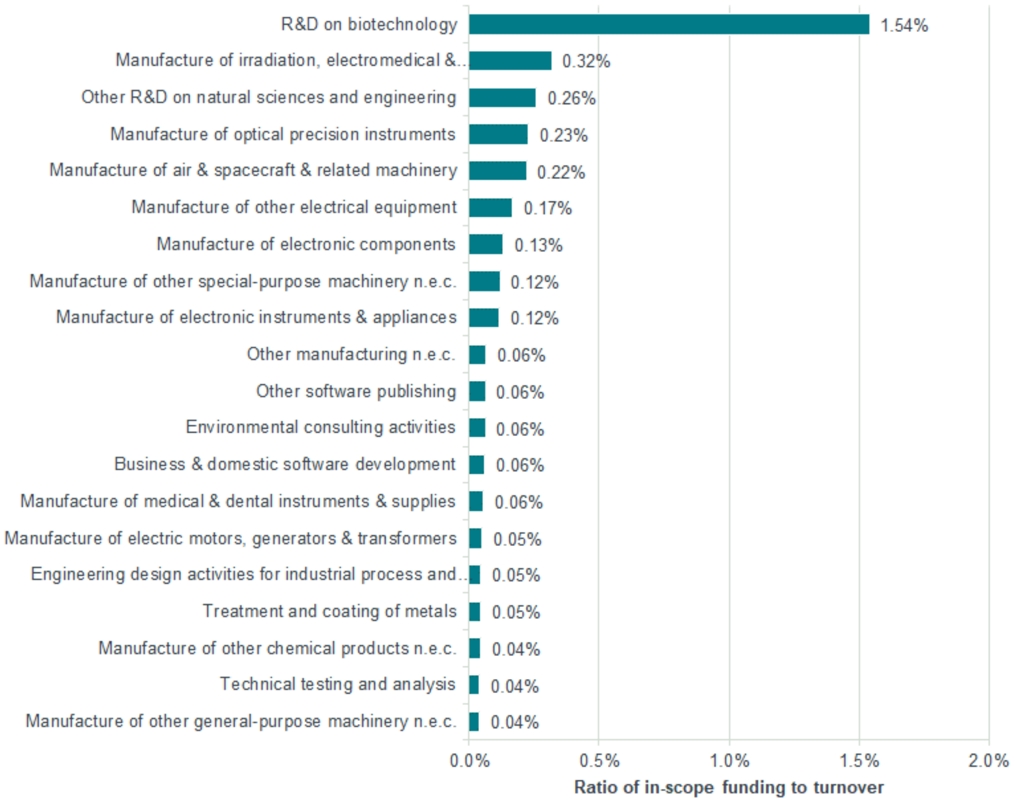
Figure 33 illustrates the SIC code sub-classes which have received the largest amount of Innovate UK aid as a percentage of market turnover in that sub-class. In all cases, Innovate UK aid is small in relation to industry turnover. Even in the *Research and experimental development on biotechnology* SIC code which is ranked number one, the aid awarded only accounted for 1.45% of turnover in 2015/16. The most affected markets (where Innovate UK aid is at least 0.20% of market turnover) are:

- *Research and experimental development on biotechnology*;
- *Manufacture of irradiation, electromedical & electrotherapeutic equipment*;
- *Other research and experimental development on natural sciences and engineering*;
- *Manufacture of optical precision instruments*; and
- *Manufacture of air and spacecraft and related machinery*.

In all markets other than *Research and experimental development on biotechnology*, the exact ratio of aid to turnover is relatively low. One might not necessarily expect a significant difference in the likelihood of competition and trade impacts between markets when the aid received is consistently at a low level across markets.

Comparing Figure 32 and Figure 33, it is notable that some of the markets that receive the most funding in absolute terms, do not have a particularly high ratio of funding-to-turnover and thus do not feature in Figure 33 because the total size of the market is very large (e.g. *Manufacture of motor vehicles* and *IT consultancy activities*).

Figure 33 Top 20 SIC codes (five-digit granularity) receiving Innovate UK funding relative to turnover (2015/16, %)



Source: IUK funding data, Frontier analysis of ONS data (Business Structure Database)

Notes: Excludes SIC codes with fewer than 10 funded firms in 2014/15, 2015/16 or 2016/17

Figure 34 provides additional detail on funding and market size for SIC codes with a high ratio of funding to turnover (top 15 SIC codes). *Manufacture of air and spacecraft and related machinery* is the largest of these SIC codes with total market turnover of £32,381 million compared to just £543 million for *Manufacture of optical precision instruments*. Despite this, since *Manufacture of air and spacecraft and related machinery SIC code* receives 60 times the amount of funding as *Manufacture of optical precision instruments*, both SIC codes have a similar funding-to-turnover ratio of c.0.2%.

Figure 34 Funding and turnover in SIC codes (five-digit granularity) (2015/16)

	Turnover (£m)	In-scope funding (£m)	Ratio of funding to turnover
R&D on biotechnology	1,039	16.0	1.54%
Manufacture of irradiation, electromedical & electrotherapeutic equipment	839	2.7	0.32%
Other R&D on natural sciences & engineering	16,301	42.4	0.26%
Manufacture of optical precision instruments	543	1.2	0.23%

	Turnover (£m)	In-scope funding (£m)	Ratio of funding to turnover
Manufacture of air & spacecraft & related machinery	32,381	71.8	0.22%
Manufacture of other electrical equipment	1,209	2.0	0.17%
Manufacture of electronic components	1,822	2.4	0.13%
Manufacture of other special-purpose machinery n.e.c.	1,565	1.9	0.12%
Manufacture of electronic instruments & appliances	7,425	8.8	0.12%
Other manufacturing n.e.c.	2,327	1.5	0.06%
Other software publishing	1,857	1.2	0.06%
Environmental consulting activities	1,272	0.8	0.06%
Business & domestic software development	19,130	11.4	0.06%
Manufacture of medical & dental instruments & supplies	5,019	2.9	0.06%
Manufacture of electric motors, generators and transformers	2,651	1.3	0.05%

Source: IUK funding data, Frontier analysis of ONS data (Business Structure Database)

Notes: Excludes SIC codes with fewer than 10 funded firms in 2014/15, 2015/16 or 2016/17

6.3.2 Number of beneficiary firms

Figure 35 shows the number of funded firms as well as the total number of firms in these SIC codes. *Other R&D on natural sciences and engineering* had the most funded firms in 2015/16 followed by *Business & domestic software development* and *Research and experimental development on biotechnology.* On the other hand, some of the SIC codes with high ratios of funding to turnover had relatively few funded firms in 2015/16 (e.g. *Manufacture of irradiation, electromedical & electrotherapeutic equipment*, *Manufacture of optical precision instruments* and *Manufacture of other electrical equipment*).

Figure 35 Total and funded firms in SIC codes with highest funding to turnover ratio (five-digit granularity) (2015/16)

	Funded firms	Total firms	Ratio funded to total firms
R&D on biotechnology	94	893	10.53%
Manufacture of irradiation, electromedical & electrotherapeutic equipment	10	140	7.14%
Other R&D on natural sciences & engineering	287	3,985	7.20%
Manufacture of optical precision instruments	18	232	7.76%
Manufacture of air & spacecraft & related machinery	25	872	2.87%

	Funded firms	Total firms	Ratio funded to total firms
Manufacture of other electrical equipment	18	789	2.28%
Manufacture of electronic components	39	652	5.98%
Manufacture of other special-purpose machinery n.e.c.	17	574	2.96%
Manufacture of electronic instruments & appliances	56	1,531	3.66%
Other manufacturing n.e.c.	18	4,719	0.38%
Other software publishing	15	2,257	0.66%
Environmental consulting activities	12	3,268	0.37%
Business & domestic software development	134	31,266	0.43%
Manufacture of medical & dental instruments & supplies	38	2,048	1.86%
Manufacture of electric motors, generators and transformers	15	312	4.81%

Source: *IUK funding data, Frontier analysis of ONS data (Business Structure Database)*

Notes: *Excludes SIC codes with fewer than 10 funded firms in 2014/15, 2015/16 or 2016/17*

6.3.3 Proxy for economic market

Examples of the activities undertaken by firms in these markets are provided in Figure 36. This shows that 5 of the 15 SIC codes capture "Other" activities that are not otherwise classified:

- Other R&D on natural sciences and engineering
- Manufacture of other electrical equipment
- Manufacture of other special-purpose machinery n.e.c.
- Other manufacturing n.e.c., and
- Other software publishing

As a result, these SIC codes may not proxy well for economic markets – they are likely to contain firms performing a wide variety of activities that may not be closely related and may be facing very different competitive conditions. The same can be said for some other very broad SIC codes such as *26511 - Manufacture of electronic instruments and appliances for measuring, checking, testing, navigation and other purposes, except industrial process control equipment.*

Figure 36 Examples of activities for selected SIC codes

SIC Name	Examples of activities
72110 - Research and experimental development on biotechnology	Research and experimental development on DNA/RNA, proteins and other molecules, cell and tissue culture and engineering, fermentation, gene and RNA vectors, and nanobiotechnology.
26600 – Manufacture of irradiation, electromedical & electrotherapeutic equipment	Includes manufacture of irradiation apparatus and tubes, CT scanners, PET scanners, MRI equipment, medical ultrasound equipment, electrocardiographs, electromedical endoscopic equipment, medical laser equipment, pacemakers and hearing aids.

SIC Name	Examples of activities
72190 - Other research and experimental development on natural sciences and engineering	Research and experimental development on natural sciences, engineering and technology, medical sciences and agricultural sciences excluding biotech.
26701 - Manufacture of optical precision instruments	Manufacture of binoculars, microscopes, telescopes, prisms, lenses, the coating or polishing of lenses and the mounting of lenses.
30300 - Manufacture of air and spacecraft and related machinery	Manufacture of aeroplanes, helicopters, gliders, hang-gliders and hot air balloons (including parts and accessories of aircraft such as wings, doors, fuel tanks, aircraft engines, rotor blades and turbojets). Also includes the manufacture of spacecraft, satellites, planetary probes, orbital stations, shuttles and intercontinental ballistic missiles.
27900 - Manufacture of other electrical equipment	Manufacture of misc. electrical equipment other than motors, generators and transformers, batteries and accumulators, wires and wiring devices, lighting equipment or domestic appliances.
26110 - Manufacture of electronic components	The manufacture of semiconductors and other components for electronic applications. This includes the manufacture of capacitors, resistors, microprocessors, electron tubes, electronic connectors, integrated circuits, transistors, inductors, LEDs, printer cables, monitor cables , USB cables and connectors.
28990 - Manufacture of other special-purpose machinery n.e.c.	Manufacture of machinery for exclusive use in a specific industry or a small cluster of specific industries including (i) dryers for wood, paper pulp, paper or paperboard, (ii) printing and bookbinding machines, (iii) machinery for tiles, bricks, shaped ceramic pastes, pipes, graphite electrodes and blackboard chalk, (iv) semi-conductor manufacturing machinery and (v) industrial robots.
26511 - Manufacture of electronic instruments and appliances	Manufacturing of search, detection, navigation, guidance, aeronautical, and nautical systems and instruments; automatic controls and regulators for applications, such as heating, air conditioning, refrigeration and appliances; instruments and devices for measuring, displaying, indicating, recording, transmitting, and controlling temperature, humidity, pressure, vacuum, combustion, flow, level, viscosity, density, acidity, concentration, and rotation; totalising fluid meters and counting devices; instruments for measuring and testing the characteristics of electricity and electrical signals; instruments and instrumentation systems for laboratory analysis of the chemical or physical composition or concentration of samples of solid, fluid, gaseous, or composite material; other measuring and testing instruments and parts thereof.
32990 - Other manufacturing n.e.c.	Manufacture of protective safety equipment, pens and pencils, globes, umbrellas, sun-umbrellas, walking sticks, seat-sticks, buttons, press-fasteners, snap-fasteners, press-studs, slide fasteners, cigarette lighters, smoking pipes, combs, hair slides, scent sprays, vacuum flasks and other vacuum vessels for personal or household use, wigs, false beards, eyebrows, candles, tapers and the like; artificial flowers, fruit and foliage; jokes and novelties; hand sieves and hand riddles; tailors' dummies; burial coffins, floral baskets, bouquets, wreaths etc.
58290 - Other software publishing	Publishing of ready-made (non-customised) software, including translation or adaptation of non-customised software for a particular market.
47901 – Environmental consulting activities	Consulting activities for environmental projects. Generally delivered to commercial clients. Includes activities for which more advanced professional, scientific and technical skill levels are required. Does not include ongoing, routine functions that are generally of short duration.
62012 - Business and domestic software development	Writing, modifying, testing and supporting of software. Writing computer code to create and implement software systems, software applications, databases and webpages. It excludes interactive leisure and entertainment software, such as games software.
32500 - Manufacture of medical and dental instruments and supplies	Manufacture of lab apparatus, surgical and medical instruments, surgical appliances and supplies, dental equipment and supplies, orthodontic goods, dentures, and orthodontic appliances. Included is the manufacture of medical, dental and similar furniture, where the additional specific functions determine the purpose of the product, such as dentist's chairs with built-in hydraulic functions.
27110 – Manufacture electric motors, generators & transformers	Manufacture of all electric motors and transformers: AC, DC and AC/DC.

Source: ONS (2009), UK Standard Industrial Classification of Economic Activities 2007 (SIC 2007)

6.4 Selected markets

Based on the ratio of Innovate UK funding to market size (including whether SIC codes related to high priority sectors/challenges for Innovate UK), the number of beneficiary firms and the extent to which a given SIC code is a good proxy for an economic market we selected the following four markets for competition and trade analysis:

- *Research and experimental development on biotechnology*;
- *Manufacture of medical and dental instruments and supplies*;
- *Manufacture of air and spacecraft and related machinery*; and
- *Manufacture of electronic components*.

In-scope funding to private sector businesses in our four chosen SIC codes sums to £93 million, which accounts for over 30% of IUK aid awarded to private sector business in 2015/16.

We excluded some SIC codes with a high ratio of funding to market size because:

- they contained relatively few funded firms[115] (e.g. *Manufacture of optical precision instruments; Manufacture of irradiation, electromedical & electrotherapeutic equipment*) and / or
- they captured too disparate a range of activities as reflected in:
  - either the SIC code name as capturing "Other" activities (e.g. *Other R&D on natural sciences and engineering*; *Manufacture of other electrical equipment; Other software publishing*; *Manufacture of other special-purpose machinery n.e.c.*), or
  - the ONS' description of activities conducted within the SIC code (e.g. *Manufacture of electronic instruments and appliances*), or
  - the SIC code containing many thousands of firms (e.g. *Business & domestic software development*).
- for the sake of variety, we decided to focus on one electronic equipment/component type SIC code, even though multiple electronics SIC codes had a relatively high ratio of funding to market size.

Each of the four SIC codes chosen is amongst the SIC codes with the highest ratios of funding to market size (even if these are considered low in absolute terms), contains at least 25 funded firms in 2015/16 and contains firms engaging in broadly similar economic activities. In addition, this choice of SIC codes provides good variety (manufacture of aircraft is clearly very different to biotechnology research) and each SIC code chosen reflects a high priority area for IUK.

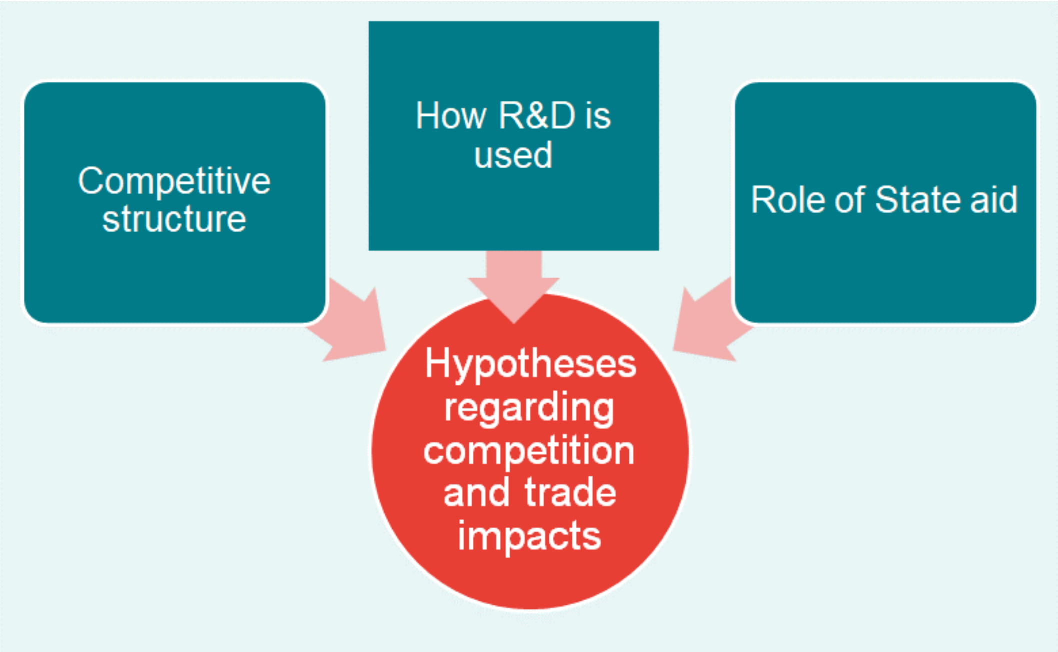
[115] This reduces the likelihood of market-wide competitive impacts

7 INDIRECT IMPACTS ON COMPETITION: DEVELOPMENT OF HYPOTHESES

7.1 Introduction

Having selected four SIC codes, we form testable hypotheses about the potential impacts of Innovate UK (IUK) State aid on competition and trade in our selected markets. The specific hypotheses we develop are informed by the competitive structure of the market, how R&D is used in the market and the role of State aid in the market. This is summarised in Figure 37.

Figure 37 Describing chosen markets to inform identification of hypotheses concerning competition and trade impacts



Source: Frontier

Based on the characteristics of each market and role played by State aid we then draw from a list of possible distortions based on whether or not it is relevant for the market in question. These distortions include:

- Creating or strengthening a dominant position (at any level of the value chain);
- Disincentivising entry of efficient competitors;
- Disincentivising R&D activity by existing or potential competitors;
- Exit of efficient competitors;
- Maintaining a market position of inefficient competitors (at any level of the value chain); and
- Location decisions across members states.

7.1.1 Competitive structure and how R&D is used

The competitive structure of our markets is important for informing our choice of relevant hypotheses regarding competition and trade impacts. To understand the competitive structure of our markets, we draw on market-based publications, including previous European Commission (EC) market investigations and merger assessments, and conduct our own quantitative descriptive analysis using the Business Structure Database (BSD) and other (Office for National Statistics) ONS publications.[116]

7.1.2 How R&D is used

Understanding which companies in the market engage in R&D, and how and why they engage in R&D, can provide useful information about the types of competition and trade impacts that R&D funding may cause. Market-based publications and ONS data (ONS 2019 A) on R&D expenditure are useful sources in this regard.

7.1.3 Role of State aid

We also consider the role of State aid in each of our markets. For example, we analyse how much aid is awarded and which in-scope programmes award the aid, using IUK funding data and the BSD. In addition, we draw on the funding rules for the aid scheme competitions that tend to attract applications from firms within our chosen markets, especially the Biomedical Catalyst competitions (which are popular with firms in the *R&D on biotechnology* and *manufacture of medical and dental instruments* SIC codes) and Aerospace Technology Institute (ATI) competitions (which are popular with firms in the aerospace sector).

We also consider some example projects to give us a greater understanding of the topics that projects focus on and the types of firms who work on these projects. Although, for confidentiality reasons, we are unable to use the BSD to identify individual firms in our chosen SIC codes, we have been able to use another micro level data source called FAME (Bureau van Dijk Electronic Publishing, 2019).[117] FAME allows us to add a SIC code variable to the IUK funding dataset and therefore determine which firms in our chosen markets received funding from IUK. All our example projects are based on firms receiving funding in 2015/16.

Figure 38 summarises the key questions our descriptive analysis tries to answer for our selected markets and our approach to answer these questions. The descriptive analysis is primarily focused on recent trends in affected markets and the current competitive landscape. Actual testing of ex post potential competition distortions will utilise the most up-to-date data available and will also draw on stakeholders' forward-looking perceptions.

[116] In our analysis, each business is allocated a single SIC code as specified in the 2017 publication of the BSD (where this is not possible because the business ceased to exist prior to the 2017 BSD publication, we use the most recently available BSD publication in which the business is present). This avoids the issue of businesses moving between SIC codes, which could otherwise distort sector trends over time.

[117] FAME is a financial reporting dataset produced by Bureau van Dijk Electronic Publishing. It includes balance sheet information for UK firms and variables related to firm performance and firm finance.

Figure 38 Describing our selected markets

	Questions for descriptive analysis	Approach
Competitive structure	▪ How many companies in the market? ▪ At what level does competition take place? Can the market be divided into segments and sub-segments? ▪ What does the supply chain / product life-cycle look like? ▪ What are the trends in the number of business in the market, market revenue and market exports.	▪ Quantitative analysis using the BSD ▪ Market-based publications including EC market investigations
How R&D is used	▪ What is total annual R&D expenditure in the market? ▪ What types of company engage in R&D in this market? ▪ What is the length of the R&D process? ▪ What is the importance of innovation in the market? ▪ What role does Intellectual Property play in the market?	▪ ONS business surveys ▪ Market-based publications including EC market investigations
Role of State aid	▪ What are the trends in the number of funded businesses in the market and the total amount of funding distributed to these firms? ▪ Which in-scope programmes are contributing the most aid to these specific SIC codes? ▪ What topics do the projects focus on? Are there any clusters of activity within our SIC codes? ▪ Who are the recipient companies? ▪ How much funding was committed to example projects in 2015/16?	▪ Innovate UK funding data and BSD ▪ Innovate UK aid scheme competition rules ▪ FAME

Source: Frontier

7.1.4 Hypotheses

Any first-order effects of the aid scheme are likely to be on the supply side.[118] However, aid may result in changes in firm behaviour that generate further impacts on the demand side of our chosen markets. Our hypotheses focus primarily on supply-side effects while also taking into account the potential for demand-side effects.

7.2 R&D on biotechnology

7.2.1 Competitive structure and how R&D is used

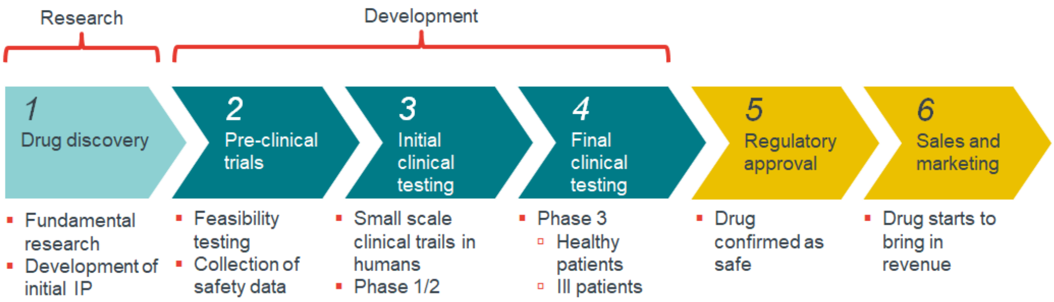
As noted in Figure 36, the *Research and experimental development on biotechnology* SIC code includes companies for whom their primary economic activity includes research and experimental development on DNA/RNA, proteins and other molecules, cell and tissue culture and engineering, fermentation, gene and RNA vectors, or nanobiotechnology

The main application of biotechnology is the supply of medicines.[119] As such, the main focus of companies in this SIC code is on reaching unmet medical needs by researching and developing new medicines and bringing them to market. Figure 39 shows the life-cycle of a new medicine that is successfully brought to market.

[118] This is in line with Oxera's report on the Ex Post Assessment of the Impact of State Aid on Competition, which was published by the EC in 2017 and states: '…state aid is often supposed to result in lower prices and higher quality. The aim of state aid control is therefore to identify possible competitive distortions arising from changes in firm behaviour triggered by the receipt of aid'.

[119] Biotechnology can also be used in agricultural applications but IUK's funding is focused on the medical side.

Figure 39 Life-cycle of a medicine that gets to market



Source: Frontier adapted from EC, Pharmaceutical Sector Inquiry Final Report (EC, 2009 B)

As explained in the EC's Pharmaceutical Sector Inquiry (EC, 2009 B) and recent follow-up (EC, 2019), the life-cycle of a new drug begins with fundamental research into a new chemical compound – **drug discovery**. The fundamental research is usually conducted by biotechnology companies or within universities.[120] Patents registered at this stage are often referred to as 'primary patents' because they relate to the first patents for the active molecules.

Following the research phase comes a development phase in which biotechnology companies test whether a drug containing their chemical compound would be safe and effective. Testing can generally be divided into three main stages: **pre-clinical trials**, **initial clinical trials** and **final clinical trials:**

- **Pre-clinical trials** involve laboratory and animal testing principally aimed at determining toxicity.
- **Initial clinical testing** involves Phase I trials (studies on small groups of healthy human beings to determine safety and side effects) and Phase II trials (studies on patients with the disease, who are often chronically or even terminally ill, to test the efficacy of the new medicine for the given indication).
- **Final clinical testing**, known as Phase III trials, which involve large patient groups (very often thousands of patients with the illness to be treated).[121]

Once studies have shown that a new medicine is effective and safe, the company can apply to the regulatory agency for **regulatory approval/marketing authorisation**. This could be either the European Medicines Agency or a national authority.[122] Only at this point can **sales and marketing** begin, and a medicine can start to bring in revenue.[123]

Bringing a drug to market is a long and costly process. By the time a medicinal product reaches the market, an average of 12-13 years will have elapsed since the first synthesis of the new active substance (10 years for R&D and 2-3 years for

[120] Drug discovery is sometimes broken down further into **target identification** (identify molecular targets associated with the disease in question), **target validation** (verify how the targets regulate the biological processes in the body and whether they are suitable as a target for a therapeutic agent), **lead identification** (identify one or more molecules which show promise as potential treatments for the disease) and **lead optimisation** (find molecules with the greatest potential to be developed into a safe and effective medicine).

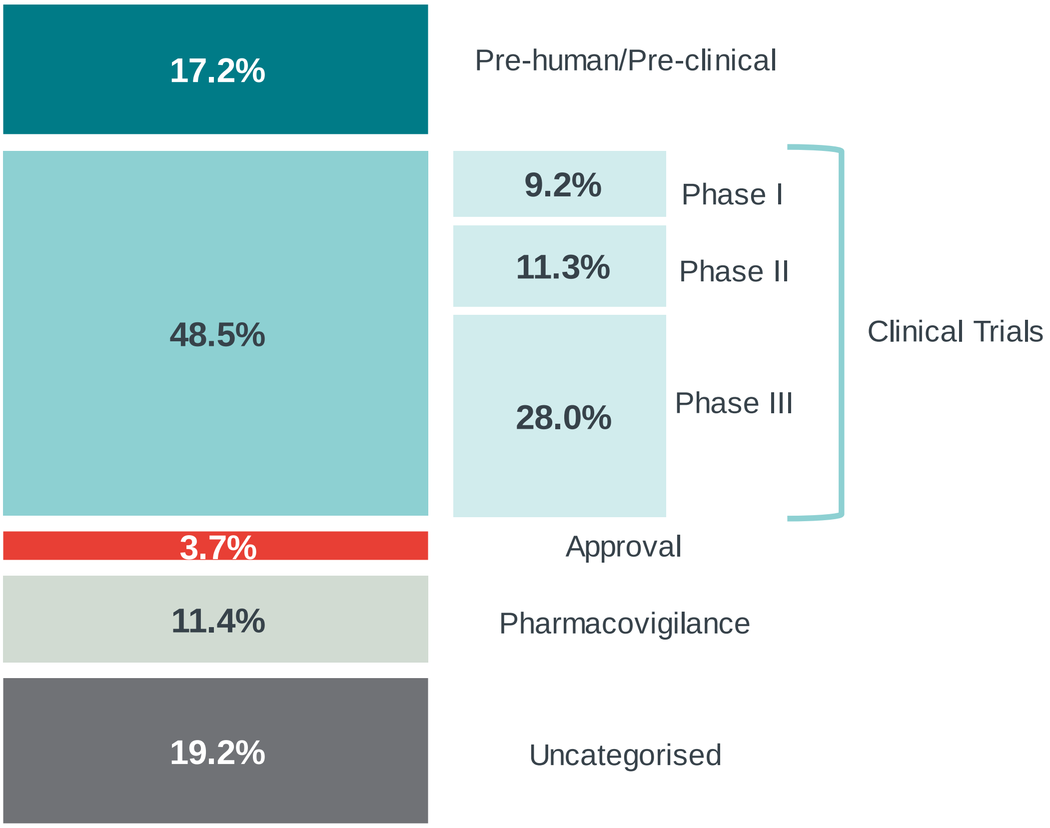
[121] In Phase II and Phase III, the development of novel pharmaceutical formulations, dosage forms and therapeutic applications may be necessary and result in the filing of further (secondary) patent applications.

[122] In addition, in many EU Member States a product can only be marketed after a decision on the price and reimbursement has been taken.

[123] Following their market launch, products continue to be monitored for possible adverse reactions and/or new side effects (also referred to as Phase IV studies).

administrative procedures).[124] Recent estimates suggest that the costs of bringing a medicine from the lab to the market are between €0.5 billion and €2.2 billion (converted from USD) (Copenhagen Economics, 2018).[125] The split of R&D costs across different stages of drug development is shown in Figure 40 – Phase III trials appear particularly expensive, accounting for 28% of R&D costs.

Figure 40 Allocation of R&D investments by function (%)



Source: PhRMA[126]

Given the high development costs and risks involved, as well as the fact that once a new medicine has been developed by an R&D biotechnology company it is relatively easy for rivals to copy it, legislation grants originator biotechnology companies various exclusivity mechanisms that are designed to provide them with incentives to invest in new R&D projects. These exclusivities are limited in time, and thus allow the entry of generic medicines at the end of the exclusivity.

In the UK, the total number of biotechnology companies has grown strongly over time, as shown in Figure 41. Between 2010/11 and 2016/17 the number of firms in

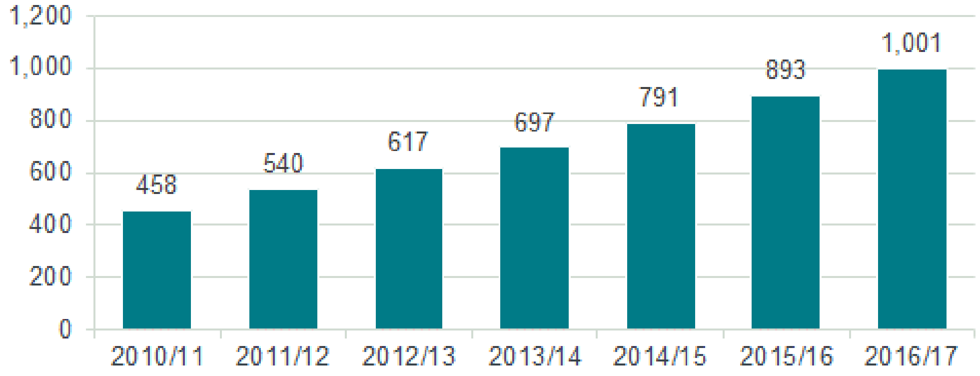
[124] European Federation of Pharmaceutical Industries and Associations, The Pharmaceutical Industry in Figures.

[125] European Commission, Report from the Commission to the Council and the European Parliament Competition Enforcement in the Pharmaceutical Sector (2009-2017) (EC, 2019), via Copenhagen Economics, Study on the Economic Impact of Supplementary Protection Certificates, Pharmaceutical Incentives and Rewards in Europe, Final Report (Copenhagen Economics, 2018), available at: https://ec.europa.eu/health/sites/health/files/human-use/docs/pharmaceuticals_incentives_study_en.pdf

[126] European Federation of Pharmaceutical Industries and Associations, The Pharmaceutical Industry in Figures.

the biotechnology SIC code increased from 458 to 1,001, a compound annual growth rate (CAGR) of 14%.

Figure 41 Number of businesses in R&D in biotechnology



Source: Frontier analysis of ONS data (Business Structure Database)

Note: (1) 2016/17 refers to the 2018 BSD publication. (2) Excludes enterprises with a legal status defined as public sector, central government, local authority or non-profits.

Most biotechnology companies are small (in 2015/16, 88% employed fewer than 10 people) and young (in 2015/16, 77% had only existed for less than 5 years). As a result, many biotechnology companies specialise in a well-defined and narrow field (niche) such as focusing on specific indications or pharmaceutical formulations. As a result, many biotechnology companies specialise in a well-defined and narrow field (niche) such as focusing on specific indications or pharmaceutical formulations. The high degree of specialisation may suggest that specific niches within the SIC code may be highly concentrated even though evidence suggests that the SIC code as a whole is not. In addition, specialisation may reflect the fact that many biotechnology companies are still developing their first products and lack the resources required to conduct all necessary steps from basic research to the marketing and distribution of the finished product. Many biotechnology companies therefore decide to out-license or sell their innovations to larger companies who have the resources to conduct clinical trials and the necessary marketing (EC, 2009 B).

Biotechnology companies may carry out their activities alone or in collaboration with other companies or entities of various types such as universities and research institutes. The collaboration can take a number of forms, including joint-research and licensing agreements, co-development and co-marketing agreements, co-promotion and joint ventures (EC, 2009 B).

Biotechnology companies are part of the wider life sciences sector (House of Commons Committee on Exiting the European Union, 2017 A), which also includes companies in other SIC codes such as

- *21100 – Basic pharmaceuticals*;
- *21200 – Pharmaceutical products and preparations*;
- *26600 – Irradiation, electromedical & electrotherapeutic equipment*; and
- *32500 – Medical and dental instruments and supplies*.

Given this background, it is unsurprising that R&D on biotechnology is one of the most R&D-intensive industries (EC, 2019).

If successful, this R&D can result in significant healthcare benefits when new medicines for previously untreated conditions or medicines which treat given conditions more effectively and/or with fewer side effects are brought to market. In addition, R&D can lead to the discovery that an existing medicine can be used for other conditions for which it has not previously been prescribed.

Healthcare benefits are likely to be particularly significant when R&D leads to new medicines for previously untreated conditions. The EU has between 5,000 and 8,000 rare diseases, defined as affecting fewer than five people in 10,000 in the EU. Although their prevalence is low, rare diseases affect 27 to 36 million people in the EU (6-8% of the population). Despite more than 1,500 treatments for rare diseases having been granted designations by the EC since the year 2000 (EC, 2015 B), most rare diseases have no cure.

Competition between biotechnology companies takes two main forms:

- First, there is **competition in the market**. This is direct competition between products of two or more companies prescribed for the same treatment. Different treatments can exist for the same illness. Therefore, competition in the market can exist as long as there is some degree of substitutability between products belonging to the same therapeutic area. Companies in the market can face competition from other companies who have their own patented drugs and companies who manufacture generic products.[127]
- Second, there is **competition for the market.** Competition for the market takes place over a longer time period and involves innovation in order to bring a product with limited substitutability to the market.

There are likely also to be intermediate cases in addition to the two examples we present above, whereby developing alternative treatments is possible but there is a significant first-mover advantage.

The key parameters of competition are likely to be relative efficacy, absence of side-effects, access to capital, intellectual property rights, marketing and possibly pricing (depending on national pricing and reimbursement systems).

From a competition standpoint, the *R&D on biotechnology* SIC code contains many different economic markets. As with any industry these markets will comprise both a product dimension (which other products exert significant competitive pressure on the investigated product) and the geographic dimension (sufficiently homogeneous area from which significant competitive pressure is exerted). To understand which medicines belong to the same economic market, one would need to assess both demand-side substitution (e.g. whether prescribers and patients would readily switch from one product to another) and supply-side substitution (the existence, or not, of suppliers that could also start producing a specific medicine) (EC, 2019).

[127] Companies with drugs in development may also provide a degree of competitive constraint on companies already in the market.

To the extent to which biotechnology companies have drugs on the market, they may compete with larger companies in other SIC codes, particularly, *21100 – Basic pharmaceuticals* and *21200 – Pharmaceutical products and preparations*.

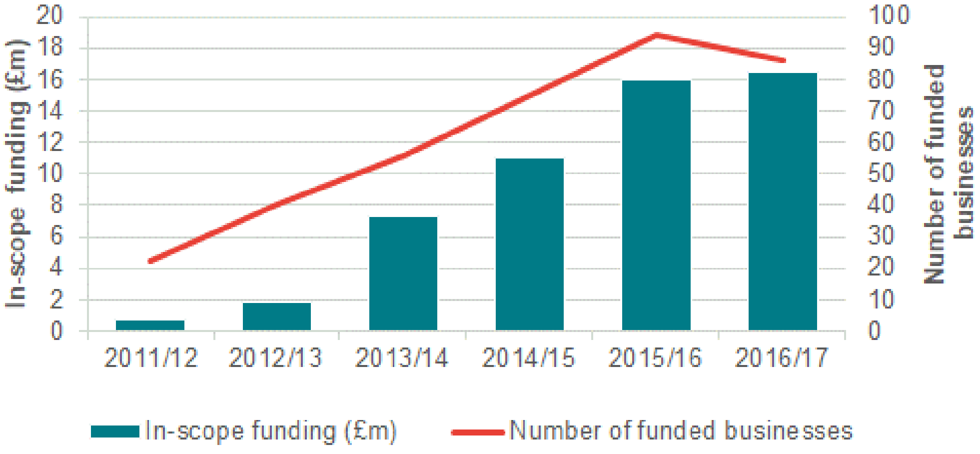
Given that biotechnology is an export-intensive industry,[128] UK biotechnology firms are likely to compete with biotechnology firms in other countries both within the EU and beyond.

7.2.2 Role of State aid

As shown in Figure 34 and Figure 35 above, there were 94 firms in the R&D on biotechnology SIC code receiving Innovate UK funding in 2015/16 aid accounted for 1.54% of sector turnover.

Figure 42 shows total in-scope aid to biotechnology firms has increased significantly over time from less than £1 million in 2011/12 to more than £15 million in 2016/17 (years prior to 2014/15 are outside the evaluation period but we still present them here by way of context). The number of funded firms has also increased significantly over time to around 80 in 2015/16 and 2016/17.

Figure 42 In-scope funding and number of funded businesses in R&D in biotechnology



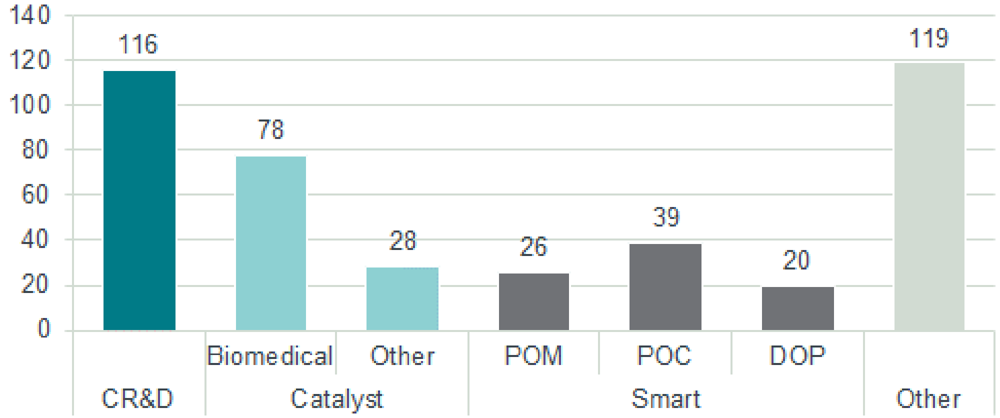
Source: Frontier analysis of Innovate UK data and ONS data (Business Structure Database)

Note: (1) 2016/17 refers to the 2018 BSD publication; (2) Excludes enterprises with a legal status defined as public sector, central government, local authority or non-profits

Figure 43 shows that this in-scope funding of biotechnology firms has come from a mixture of Innovate UK programmes including CR&D, Smart and Catalyst. Within the Catalyst programme, Biomedical Catalyst competitions have been a particularly important source of funding.

[128] One survey-based estimate suggests exports represent 79% of turnover in biotechnology: https://bbsrc.ukri.org/documents/capital-economics-biotech-britain-july-2015/

Figure 43 Number of in-scope projects undertaken by biotechnology firms by programme (2011/12 to 2017/18)



Source: Frontier analysis of Innovate UK data and ONS data (Business Structure Database); excludes enterprises with a legal status defined as public sector, central government, local authority or non-profits

Note: POM refers to Proof of Market, POC refers to Proof of Concept and DOP refers to Development of Prototype

Six examples of the largest projects receiving Innovate funding in this SIC code are shown below in Figure 44. The projects focus on the early-stage development of treatments for diseases such as cancer and schizophrenia. Total funding committed to these projects ranges from £1.2 million to £2.3 million, with aid intensity around 50-60%[129] (we will present a full analysis of intensity when assessing proportionality in Chapter 11).

Figure 44 Projects examples for R&D on biotechnology (2015/16)

Project title	Recipient company	Aid intensity	Total funding committed
Phase I study to assess tolerability, safety and PK of MGB-BP-3 in healthy volunteers	MGB Biopharma Delivering Novel Anti-Infectives	60%	£1,319,669
Development of a novel therapeutic treatment to engineer corneas to resist graft rejection	Oxford Biomedica	60%	£1,791,265
Ovarian Cancer Trial with an Enhanced Group B Oncolytic Adenovirus	PsiOxus Therapeutics	50%	£1,727,687
Development of a Kv3 Positive Modulator for the treatment of Schizophrenia	autifony therapeutics	60%	£1,241,270
First-In-Human' directed pre-clinical development of anti-cancer agent CYC140	CYCLACEL	60%	£2,264,482
Novel drug candidates for the treatment of castrate resistant prostate cancer	CellCentric	54%	£2,200,000

Source: Frontier analysis of FAME and IUK funding data

It should be noted that IUK is not the only source of non-industry funding for biotechnology research and development in the UK. According to the Office for Life Sciences, AMRC member charities (£1.6 billion) Medical Research Council

[129] As defined by IUK funding as a proportion of total project costs.

(£900 million) and National Institute for Health Research (£1 billion) all made significant contributions to health R&D expenditure in 2015/2016.[130] [131]

7.2.3 Hypotheses

The two forms of competition that take place amongst biotechnology firms – competition in the market and competition for the market – naturally lead to two hypotheses about how aid could potentially distort competition and trade by negatively affecting other non-recipient firms who are currently in the market (if the products under development potentially reduce demand for an existing product) (Hypothesis #1) or those seeking to develop a new product to enter the market (Hypothesis #2).

In addition, given the global nature of demand for medical drugs, the high trade intensity of the biotechnology industry and the importance of access to capital to biotechnology firms, we also include a third hypothesis – that the aid scheme could distort the incentives of potential recipients by encouraging them to locate in the UK or carry out R&D in the UK in order to increase their access to funding. This is in keeping with the location effect result indicator which features in the EC's Common Methodology for State Evaluation (EC, 2014 A).[132] [133]

R&D ON BIOTECHNOLOGY – HYPOTHESIS #1

The aid awarded by IUK allows firms to undertake additional R&D which in certain cases leads to the development of a new drug or medical device, which in turn causes harm to the incumbent firms or distorts their incentives

R&D ON BIOTECHNOLOGY – HYPOTHESIS #2

The aid awarded by IUK gives beneficiaries an artificial edge relative to other firms seeking to carry out R&D in the race to develop a new medicine

R&D ON BIOTECHNOLOGY – HYPOTHESIS #3

The aid has encouraged recipients to locate in the UK or carry out R&D in the UK

[130] Office for Life Sciences, Life Science Competitiveness Indicators, May 2018, Chart 2: Non-industry spend on research and development, AMRC, MRC and NIHR Annual Reports 2016: http://www.amrc.org.uk/publications; https://www.mrc.ac.uk/publications/browse/?keywords=annual+report&searchSectionID=4BC7DBBA-1972-4E8B-898B31A1B8A6EEB0; https://www.nihr.ac.uk/about-us/documents/NIHR-Annual-Report-2015-16.pdf

[131] These funds do not qualify as State aid and fall outside the scope of this evaluation.

[132] See Annex II p 36.

[133] This hypothesis will be assessed at a relatively high level as the scheme is not regional aid.

7.3 Manufacture of medical and dental instruments

7.3.1 Competitive structure and how R&D is used

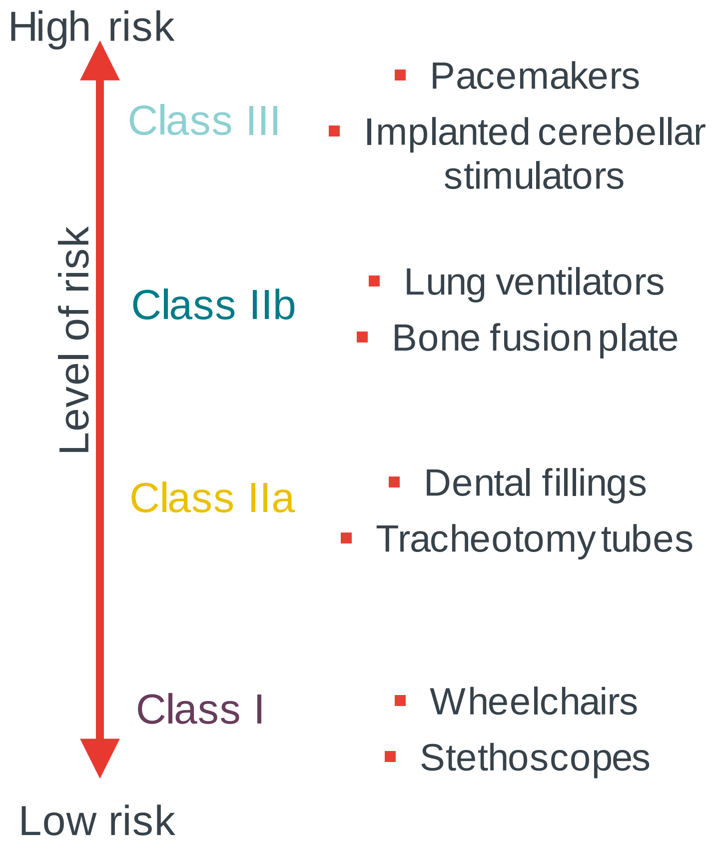
As with companies in the biotechnology sector, companies in the manufacture of medical and dental instruments are also part of the wider life sciences sector. However, whereas the drugs produced by biotechnology companies are based entirely on chemistry, medical and dental instruments are based at least partially on physics (particularly mechanical, electrical and/or materials engineering) but also have a chemical element.

There are about 10,000 different medical devices ranging from syringes and wheelchairs to pregnancy test kits, pacemakers and X-ray machines.[134] Medical devices are arguably a much more heterogenous group of products than drugs in terms of design, use, purpose and risk in development.

Countries in the EU categorise medical devices using a risk-based classification system (where risk refers to potential impact on patients rather than the risk of the product not coming to market). Devices are classified into the following classes: I, IIa, IIb, and III. Class I medical devices are associated with the lowest risk and Class III devices are associated with the highest risk. In Figure 45 below we provide some examples.

[134] Association of British Healthcare Industries.

Figure 45 Medical and dental devices by risk class



Source: MHRA[135]

The development of a typical medical device has some similarities with the development of a drug produced by a biotechnology company. As with medical drugs, the medical device industry has its own regulatory system. Medical devices must have a valid CE mark, a sign of conformity with the EU's medical device regulations, in order to be marketed within the EU.

But there are also differences; for instance, R&D time is generally much shorter for medical devices. In addition, regulatory approval for medical devices tends to be quicker.[136]

In the UK, as with the biotechnology industry, the total number of medical and dental manufacturing companies has increased over time as shown in Figure 46. In addition, comparing Figure 46 to Figure 41 suggests that the medical and dental instruments industry is larger (twice as many companies) but is growing more slowly (1.5% CAGR in the number of companies since 2010/11 compared to a 14% CAGR for R&D on biotechnology).

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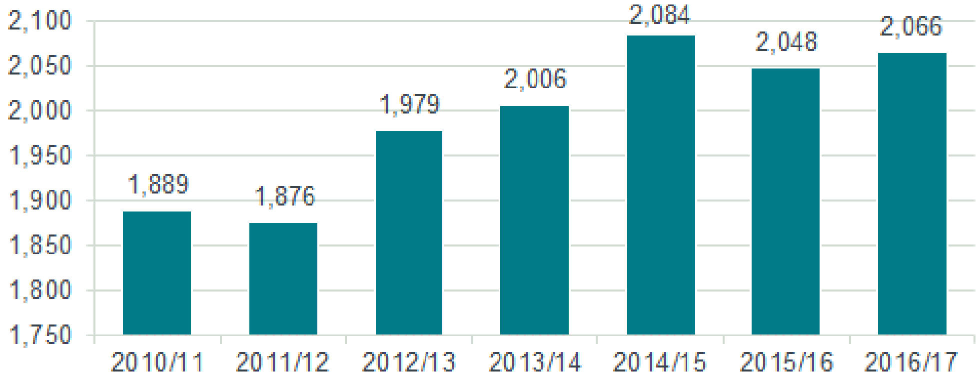
135 An introductory guide to the medical device regulation and the in vitro diagnostic medical device regulation: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/640404/MDR_IVDR_guidance_Print_13.pdf

136 Timelines for the medical device registration process can vary depending on the class of the device. For Class I devices, the registration process typically does not take more than one week. For higher classes, the timeline is dependent on product type and contract with a notified body.

Figure 46 Number of businesses in manufacture of medical and dental instruments



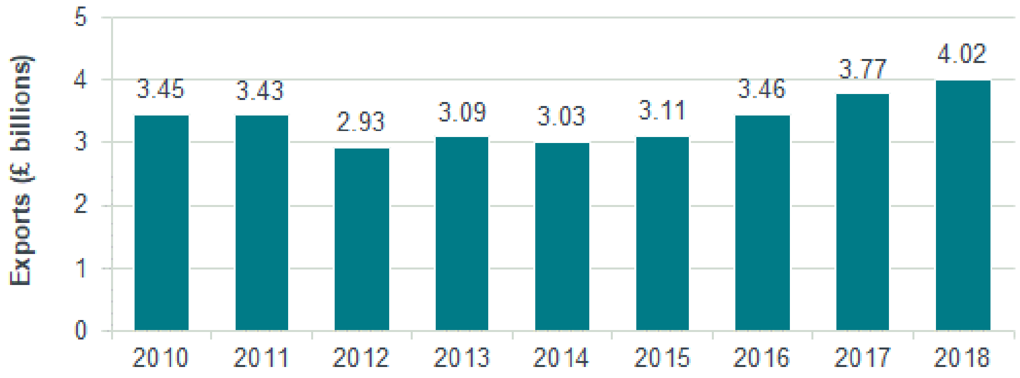
Source: Frontier analysis of ONS data (Business Structure Database)

Note: (1) 2016/17 refers to the 2018 BSD publication. (2) Excludes enterprises with a legal status defined as public sector, central government, local authority or non-profits.

Competition between medical and dental instrument manufacturers also involves competition in the market and competition for that market. Both types of competition are likely concentrated within well-defined types of devices.[137]

Figure 47 shows exports over time amongst medical and dental companies. Exports account for more than 60% of turnover in all years, suggesting that some medical and dental companies face competition from international competitors. In its market definition decisions in previous merger cases, the EC noted that competition has some national elements given that market structures vary from country to country, there are different public reimbursement systems in different countries, which result in price differences across countries, and hospital purchasing behaviour differs across countries. This suggests that global manufacturers are competing in national markets that differ from other national markets further downstream.

Figure 47 Exports in manufacture of medical and dental instruments (£ billion)



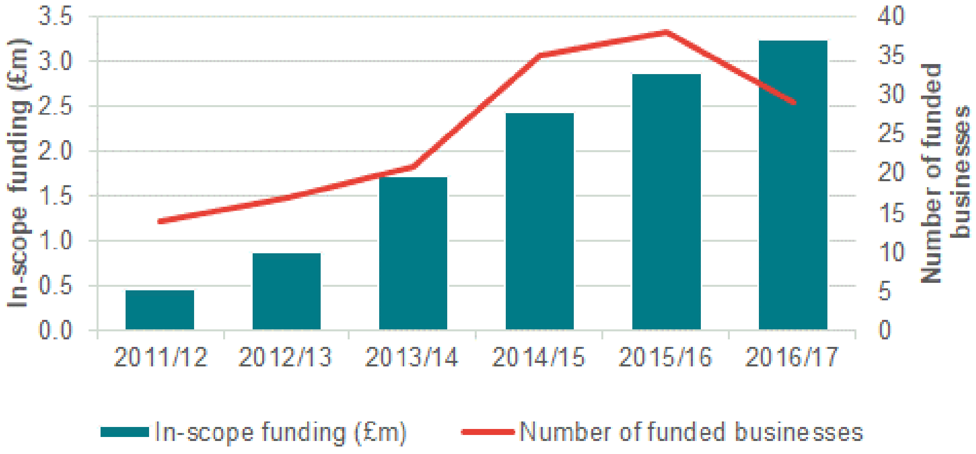
Source: Frontier analysis of UK Trade in Goods by Classification of Product by Activity, time series dataset, quarterly and annual up to and including 2018 Q4

[137] For example, when evaluating the competition implications of a proposed merger between Zimmer and Biomet, the EC considered separate product markets were appropriate for knee implants, elbow implants, hip implants, shoulder implants, bone cement, bone cement accessories, pulsed lavage, spine devices, trauma devices and dental implants.

7.3.2 Role of State aid

As shown in Figure 48, total in-scope aid to medical and dental instruments firms has increased significantly over time from £0.4 million in 2011/12 to more than £3 million in 2016/17.[138] The number of funded firms has also increased significantly over time, peaking at 38 in 2015/16.

Figure 48 In-scope funding and number of funded businesses in manufacture of medical and dental instruments

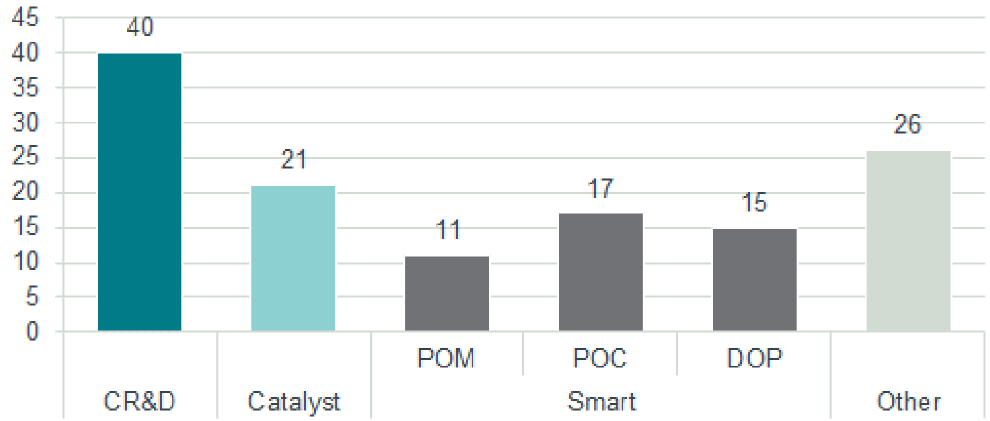


Source: Frontier analysis of IUK data and ONS data (Business Structure Database)

Note: (1) 2016/17 refers to the 2018 BSD publication. (2) Excludes enterprises with a legal status defined as public sector, central government, local authority or non-profits.

Figure 49 shows that the three types of Smart programme award have collectively funded the most in-scope projects since 2011/12 followed by the CR&D programme. Within the Smart programme, projects were a mix of proof of market, proof of concept and development of prototype.

Figure 49 Number of in-scope projects undertaken by manufacture of medical and dental instruments firms by programme (2011/12 to 2017/18)



Source: Frontier analysis of IUK data and ONS data (Business Structure Database)

138 As noted above, years prior to 2014/15 are outside the evaluation period but we still present them here by way of context.

Six examples of the largest projects funded by IUK are shown below in Figure 50. Total funding committed to these projects varies from £0.2 million to £2.1 million, with aid intensity generally around 60%.

Figure 50 Project examples for manufacture of medical and dental devices (2015/16)

Project title	Recipient company	Aid intensity	Total funding committed
Enhancement and Mapping of Oncological Drug Delivery by Ultrasound	OxSonics Therapeutics	60%	£2,124,283
Clinical Assessment of Compact Gamma Camera: An advancement in cancer diagnosis	Xstrahl	58%	£508,849
Demonstration of a Sensor Catheter Technology for the Real Time Diagnosis of Sepsis	KIMAL	60%	£267,788
Development of a molecular imaging camera to guide cancer surgery	Lightpoint Medical	44%	£250,000
Rapid determination of negative blood cultures	Momentum Bioscience	60%	£1,233,535
Early Stage Regenerative Remediation of hip OA by novel curvilinear arthroscopy	JRI	60%	£197,384

Source: Frontier analysis of FAME and IUK funding data

7.3.3 Hypotheses

There are clearly a number of similarities between companies engaged in *R&D on biotechnology* and companies engaged in the *manufacture of medical and dental instruments*. Both SIC codes are part of the wider life sciences industry, both have the potential to provide significant health benefits, both have long research and development processes, both require regulatory approval before market entry can occur and both are a key focus of IUK's Biomedical Catalyst competitions (so R&D on biotechnology companies and manufacture of medical and dental instrument companies compete with each other for IUK funding).

Because of these similarities, we adopt the same competition and trade hypotheses as selected for the biotechnology SIC code. We also present our evaluation of these hypotheses jointly in Chapter 8, while at the same time drawing out distinctions between the impact of the aid scheme on competition and trade across the two SIC codes.

MANUFACTURE OF MEDICAL & DENTAL INSTRUMENTS – HYPOTHESIS #1

The aid awarded by IUK allows firms to undertake additional R&D which in certain cases leads to the development of a new medicine, which in turn causes harm to incumbent firms in the final product market

MANUFACTURE OF MEDICAL & DENTAL INSTRUMENTS – HYPOTHESIS #2

The aid awarded by IUK allows firms to undertake additional R&D, which gives them an edge relative to other firms seeking to carry out R&D in the race to develop a new medicine

MANUFACTURE OF MEDICAL & DENTAL INSTRUMENTS – HYPOTHESIS #3

The aid has encouraged recipients to locate in the UK or carry out R&D in the UK

7.4 Manufacture of air and spacecraft and related machinery

7.4.1 Competitive structure and how R&D is used

The EC has classified aircraft into different types (EC, 2017)[139] (we show below that aircraft rather than spacecraft are the focus of IUK funding):

- **Commercial aircraft** which can be further divided into:
  - large commercial aircraft (i.e. aircraft with more than 100 seats and a range of greater than 2,000 nautical miles);
  - regional aircraft (i.e. aircraft with approximately 30-90 seats and a range of less than 2,000 nautical miles); and
  - business/corporate jets (i.e. aircraft designed for corporate activities).
- **Military aircraft** (ordered by ministries of defence to perform strategic and operational airlift missions).
- **Helicopters** (including normal and transport rotorcrafts propelled by turbine engines used for civil or military applications).
- **General aviation aircraft** (which typically seat 1-6 passengers and are generally equipped with piston-powered engines; they are used inter alia for personal/private travel, air tourism, recreational flying and air sports).

Of these different types of aircraft, large commercial aircraft (LCA) is comfortably the largest segment in economic terms, accounting for more than 90% of the total aircraft market.[140] The parts of an LCA can be simplistically split into three areas (House of Commons Committee on Exiting the European Union, 2017 B):

- structures, which include the nose, fuselage, wings, engine nacelles (which encase the engines) and tail;

[139] See for example, Case M.8425 - SAFRAN / ZODIAC AEROSPACE.

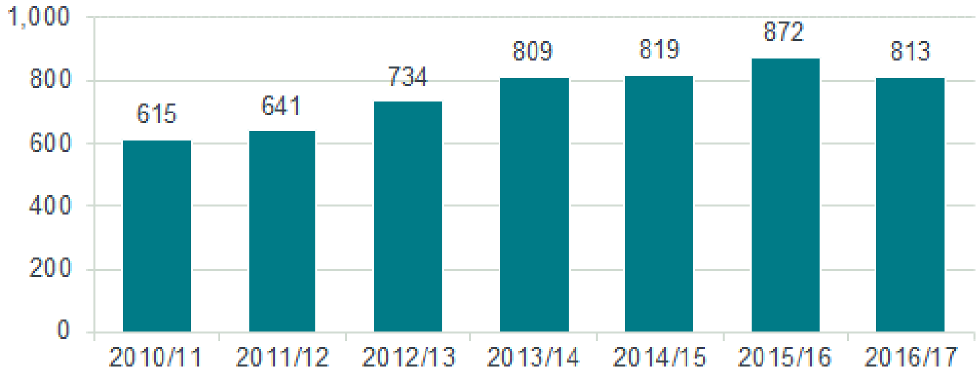
[140] https://www.cnbc.com/2019/01/25/why-the-airbus-boeing-companies-dominate-99percent-of-the-large-plane-market.html

- propulsion systems, which include engines and propellers or fan blades; and
- systems, which include the electronics used in the flight system, as well as areas such as landing gear, lighting, actuation of control surfaces and landing gear doors, heating, air conditioning, and so on.

These three areas merge to form the fourth area – whole aircraft – which includes whole aircraft modelling, integration, and safety and certification.

As shown in Figure 51, in the UK there were 813 businesses in the *manufacture of air and spacecraft and related machinery* SIC code in 2016/17. After consistent increases in the number of aerospace businesses in the UK between 2010/11 and 2015/16, there was a slight fall in the number of business in 2016/17 from 872 to 813. These businesses accounted for £38.1 billion in sales in 2016/17 (see Figure 52).

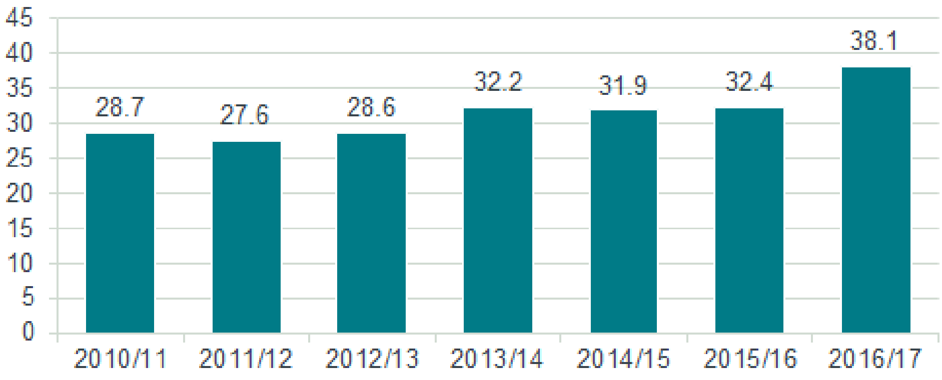
Figure 51 Number of businesses in manufacture of air and spacecraft and related machinery



Source: Frontier analysis of ONS data (Business Structure Database)

Note: (1) 2016/17 refers to the 2018 BSD publication. (2) Excludes enterprises with a legal status defined as public sector, central government, local authority or non-profits.

Figure 52 Turnover in manufacture of air and spacecraft and related machinery (£ billion)



Source: Frontier analysis of ONS data (Business Structure Database)

Note: (1) 2016/17 refers to the 2018 BSD publication. (2) Excludes enterprises with a legal status defined as public sector, central government, local authority or non-profits.

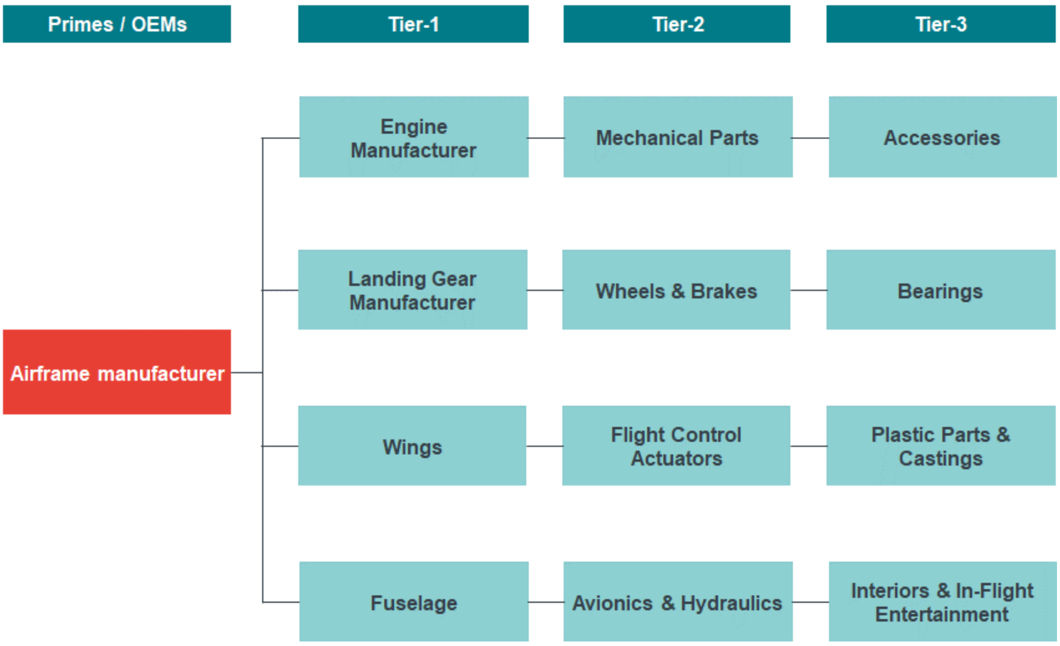
Figure 53 gives a stylised illustration of the structure of LCA supply chains. First, there are primes/Original Equipment Manufacturers (OEMs) who control the design, manufacturing and assembly of aircraft. Globally, Airbus and Boeing are the two largest OEMs, reportedly accounting for c.99% of LCA orders,[141] though other OEMs, such as the Chinese government-backed Comac, have emerged in recent years.

Feeding into OEMs are Tier 1 suppliers. Tier 1 suppliers, such as Rolls-Royce, GE Aviation, Goodrich, Spirit and GKN, support OEMs by providing equipment and systems like engines and wings. For example, there are three companies globally with the capability to design and manufacture large, civil aerospace engines – Rolls-Royce (headquartered in the UK), GE Aviation, and Pratt and Whitney (both headquartered in the USA) (House of Commons Committee on Exiting the European Union, 2017 B).

Below Tier 1 suppliers are Tier 2 suppliers, who manufacture and develop parts as per the specifications provided by OEMs and Tier 1 suppliers. Finally Tier 3 suppliers are responsible for supplying basic products, components and other non-core value-added services.

In England, aerospace manufacturing is focused in the Midlands, South West and North West, with a number of supply chain companies in these regions supporting the OEMs and Tier 1s. Clusters also exist in Wales (particularly Cardiff and Broughton), Northern Ireland (main cluster in Belfast) and Scotland (main cluster around Glasgow) (House of Commons Committee on Exiting the European Union, 2017 B).

Figure 53 Large aircraft supply chain



Source: TresVista[142]

Aerospace is a complex market, where R&D plays an important role. UK aerospace R&D was £1.5 billion in 2017, 6% of total UK R&D. R&D is important in aerospace

[141] https://www.cnbc.com/2019/01/25/why-the-airbus-boeing-companies-dominate-99percent-of-the-large-plane-market.html

[142] https://www.tresvista.com/wp-content/samples/landscaping/Research%20Report_Aerospace%20-%20Supply%20Chain%20Overview.pdf

because of the economics of aerospace manufacturing (WTO, 2010). The WTO note that the design, testing, certification, production, marketing and after-delivery support of LCA is an enormously complex and expensive undertaking, which requires huge up-front investments before any revenues are obtained from customers. A rough rule of thumb is that at least 600 airplanes of a new model must be sold before the revenues for a programme exceed the costs (WTO, 2010).

At the OEM and Tier 1 level, economies of scale are significant and arise from sunk development costs and learning effects. Economies of scope make it difficult to enter one market segment only. Switching costs make it more difficult for new producers to enter, and most airlines prefer fleet commonality. Uncertainty is considerable, making it very difficult to finance the huge development cost on capital markets.

On the demand side, the customers for LCA are principally airlines, either directly or through leasing companies, whose operations are sensitive to external events, such that when there is a downturn in the airline industry the LCA industry also suffers. Long lead times for LCA production mean that the LCA industry cannot respond rapidly to changes in demand from airlines. Thus, LCA manufacturers must engage in long-term planning to attempt to satisfy a market in which changes are expected but unforeseeable.

Previous EC competition investigations have considered that competition takes place both at a whole aircraft/OEM level and at a component level within different tiers of the supply chain. In previous competition investigations, the EC has acknowledged a certain degree of supply-side substitutability in aerospace component manufacturing on the basis of the functionality of the components and suppliers' capabilities. However, the EC has generally considered that different aircraft components constitute separate product markets due to the high degree of specialisation on the demand side.

In previous State aid cases, the EC has considered segments of the aerospace markets to be 'global', like the airline industry it serves.[143] The global market for aircraft, spacecraft and parts, excluding the UK, was worth around £142 billion in 2016. Countries besides the 27 other EU Member States accounted for £92 billion, or 65 per cent, of this global market (House of Commons Committee on Exiting the European Union, 2017 B).

A global market is consistent with the sector's export orientation. In 2017, exports accounted for £29 billion of the UK's total goods exports (nearly 80% of aerospace turnover). 30% of these exports go to the EU (ONS, 2019 B).[144] It is also consistent with the fact that sector supply chains are highly integrated globally with different nations working together to design and manufacture complex parts of aircraft. For example, Airbus has sites in France, Germany, Spain and the UK,[145] and Rolls-

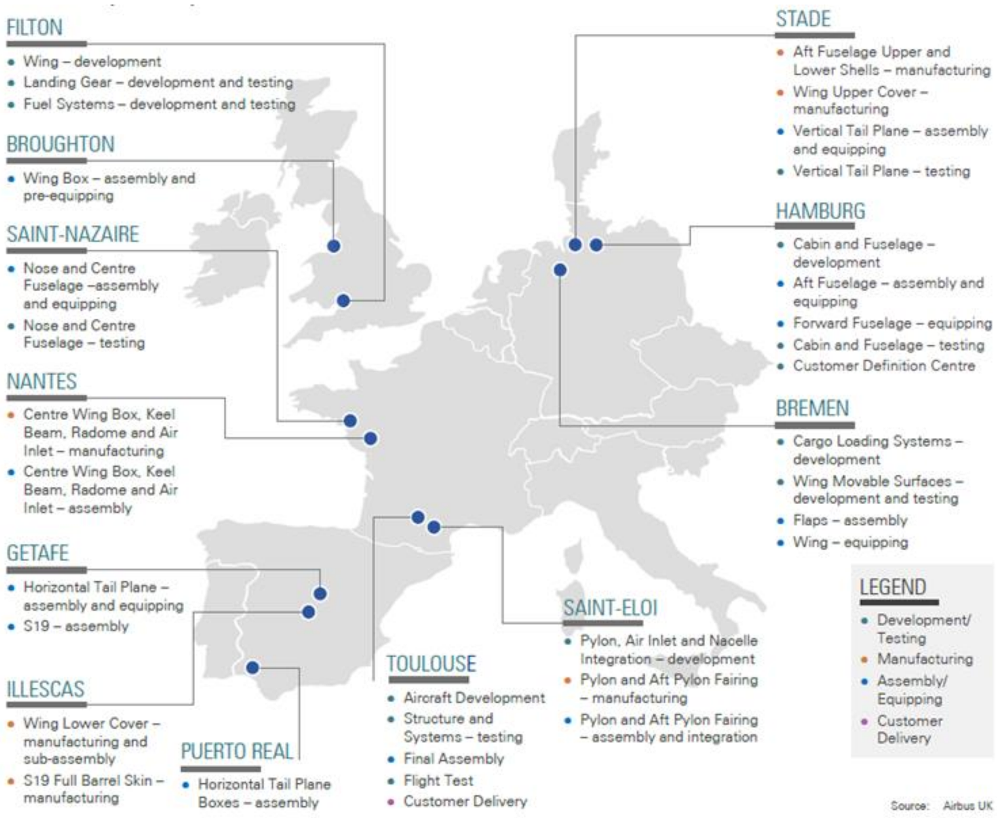
[143] For example, in Short Brothers PLC (Bombardier), the Commission examined the impact of the aid on the market for commercial aircraft in the 100-149 seating range capacity. The Commission considered this to be a 'global market characterized by negligible transportation costs and no other tangible barriers to the import of the aircrafts'. p 39, http://ec.europa.eu/competition/state_aid/cases/228939/228939_1022229_141_2.pdf

[144] UK exports can also turn into EU exports of final aircraft to non-EU countries, since a significant proportion of the total UK exports are of aircraft parts (wings, engines and landing gears) for inclusion in aircraft whose final destinations are non-EU countries, such as China and the Middle East.

[145] https://www.airbus.com/careers/our-locations/europe.html

Royce has a large presence in the UK, Germany, the USA and Singapore.[146] The European aerospace sector is particularly well integrated owing to Airbus. Figure 54 illustrates the number and breadth of locations that contribute to the manufacture of an Airbus A350 and, specifically, how the wing travels across borders to be manufactured.

Figure 54 Manufacture of wings for Airbus A350 – European footprint



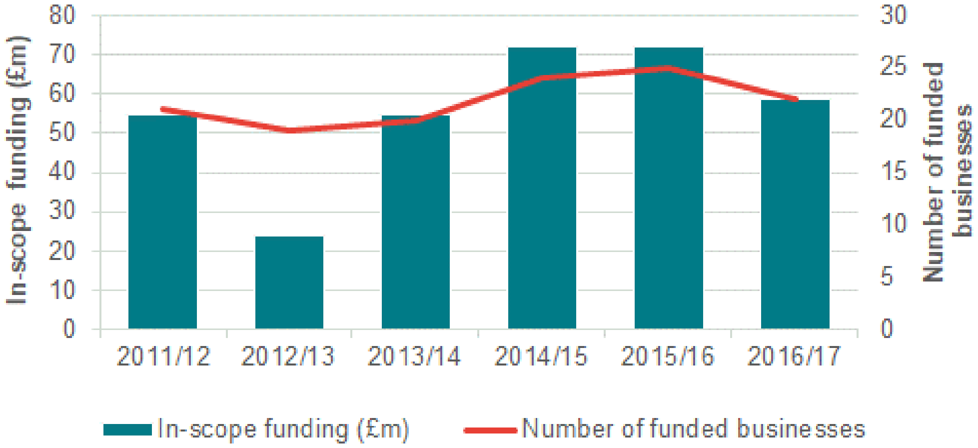
Source: Airbus UK; ADS

7.4.2 Role of State aid

More than 95% of projects funded by IUK and involving companies in the *Manufacture of air and spacecraft* SIC code have come through the CR&D programme. Figure 55 shows that in-scope programmes have consistently funded about 20 different aerospace companies each year, with around £60 million distributed in each recent year.

[146] https://careers.rolls-royce.com/our-locations

Figure 55 In-scope funding and number of funded businesses in manufacture of air and spacecraft and related machinery



Source: *Frontier analysis of IUK data and ONS data (Business Structure Database)*

Note: *(1) 2016/17 refers to the 2018 BSD publication. (2) Excludes enterprises with a legal status defined as public sector, central government, local authority or non-profits.*

One major source of funding to aerospace companies within the CR&D programme is ATI competitions.[147] In 2013, the UK government promised £150 million per year of grant funding over 13 years (2013/14-2025/26), a total of £1.95 billion grant funding, to be matched by a further £1.95 billion from industry. As of August 2019, around 65% of the £1.95 billion has been awarded to recipients so far. Of the £1.3 billion in grant awards to date, £380 million has gone to 42 research/academic organisations (universities and Catapults) – nearly 30% of the total – with the remaining 70% to the private sector – 70 large companies and 135 unique small and medium enterprises. These projects often involve multiple collaborators – the average number of partners of an ATI project is four and 20% of ATI projects have more than five partners involved. Six examples of aerospace projects are shown below.

[147] Note that not all companies funded by ATI competitions will be in the *Manufacture of air and spacecraft* SIC code. Some may be in other related SIC codes.

Figure 56 Project examples for manufacture of air and spacecraft and related machinery (2015/16)

Project title	Recipient company	Aid intensity	Total funding committed
ATI Landing Gear Project Phase 1	AIRBUS	46%	£4,740,577
Validation and Integration of Manufacturing Enablers for Future Wing Structures	GKN AEROSPACE	50%	£4,757,314
	SPIRIT AEROSYSTEMS	50%	£1,474,500
Advanced Electrical Machines Technologies for Aircraft	SAFRAN	50%	£1,698,359
Advanced Structural Integrated Demonstrator	BAE SYSTEMS	49%	£442,546
Wing Design Manufacture & Assembly	SPIRIT AEROSYSTEMS	50%	£650,160
Project 3 Flight Trials	AgustaWestland A Finmeccanica Company	22%	£2,350,000

Source: Frontier analysis of IUK data and ONS data (Business Structure Database)

7.4.3 Hypotheses

We have five hypotheses, listed below, concerning the potential for IUK aid to distort competition and trade in the manufacture of LCA.

The first two hypotheses are functions of the nature of aerospace supply chains. Given the two large OEMs at the top of the LCA supply chain, Airbus and Boeing, our first hypothesis focuses on the potential for the aid scheme to strengthen the market position of one of these OEMs. This is in keeping with a change in market power of a dominant player, which is included as a possible result indicator in the EC's Common Methodology for State Evaluation (EC, 2014 A).[148]

Relatedly, our market overview suggests that bringing a new aircraft to market requires extensive R&D covering a wide range of equipment and systems with input from multiple players. Since projects funded by the aid scheme often have multiple collaborators, our second hypothesis concerns the potential for IUK aid to help companies lower down the supply chain to secure contracts ahead of firms who do not receive funding from the aid scheme.

The third and fourth hypotheses consider the potential for aid to distort entry and exit decisions, which is particularly relevant in this case due to the significant entry barriers and high levels of concentration at the upper end of the supply chain. Hypothesis 4 is in keeping with the prevention of exit result dimension which features in the EC's Common Methodology for State Evaluation (EC, 2014 A).[149]

Finally, since our market overview suggests that aerospace markets and supply chains are at least EU wide, if not global, the fifth hypothesis considers the potential for aid to distort the incentives of potential recipients by encouraging them to locate in the UK or carry out R&D in the UK in order to increase their access to funding.

[148] See Annex II p 36.

[149] See Annex II p 36.

This is in keeping with the location effect result indicator which features in the EC's Common Methodology for State Evaluation (EC, 2014 A).[150] [151]

MANUFACTURE OF AIR AND SPACECRAFT AND RELATED MACHINERY – HYPOTHESIS #1

The aid has contributed to the increased market power of a single firm at the top of the supply chain

MANUFACTURE OF AIR AND SPACECRAFT AND RELATED MACHINERY – HYPOTHESIS #2

The aid may allow a recipient firm to artificially guarantee itself a place in future supply chains at the expense of rivals

MANUFACTURE OF AIR AND SPACECRAFT AND RELATED MACHINERY – HYPOTHESIS #3

The aid has made it more difficult for new firms to enter the industry and compete effectively

MANUFACTURE OF AIR AND SPACECRAFT AND RELATED MACHINERY – HYPOTHESIS #4

The aid has left profitable non-recipients at a competitive disadvantage, which has led to market exit. Or the aid has allowed unprofitable firms to maintain an inefficient market presence

MANUFACTURE OF AIR AND SPACECRAFT AND RELATED MACHINERY – HYPOTHESIS #5

The aid has encouraged recipients to locate in the UK or carry out R&D in the UK

[150] See Annex II p 36.

[151] This hypothesis will be assessed at a relatively high level as the scheme is not regional aid.

7.5 Manufacture of electrical components

7.5.1 Competitive structure and how R&D is used

The *manufacture of electrical components* SIC code includes companies whose primary activity is manufacturing semiconductors and other components for electronic applications. This includes the manufacture of capacitors, resistors, microprocessors, electron tubes, electronic connectors, integrated circuits, transistors, inductors, LEDs, printer cables, monitor cables, USB cables and connectors.

Electronic components are ubiquitous in modern life, not as an end in themselves but rather as an enabling technology that can be leveraged across a wide variety of industries and applications. Applications include computers, mobile phones, TVs, cars, personalised health and smart diagnostics, renewable energy and smart grids, smart mobility, smart manufacturing, smart cities and communities, sustainable food production, autonomous vehicles, and quantum computing.[152] This variety of applications means that a recent report presented to the EC considered semiconductors to be of key strategic importance to all major regions of the world (EC, 2018).

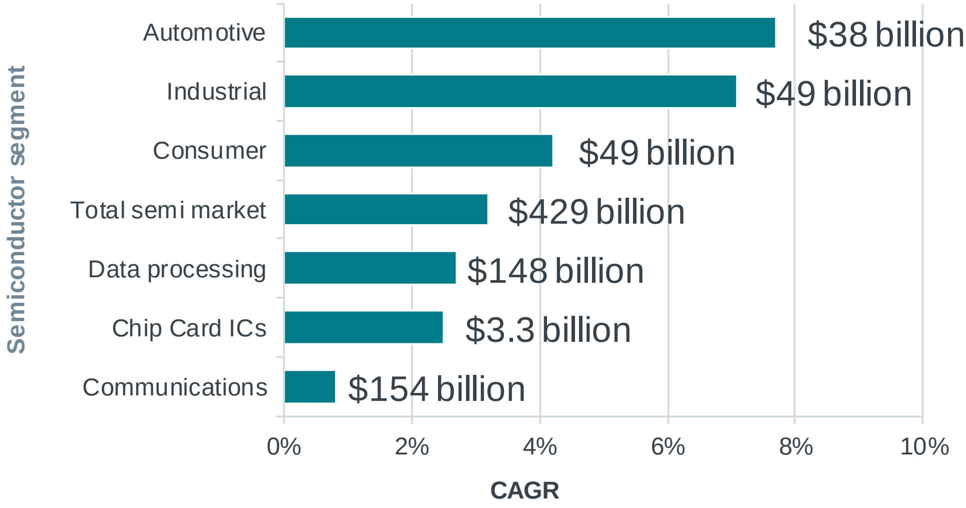
According to information provider IHS Markit, worldwide semiconductor and electrical components revenue totalled $429 billion in 2017,[153] with c.10% of this revenue accruing to companies within the EU.[154] Figure 57 shows that this $429 billion in revenue can be divided between communications ($154 billion), data processing ($148 billion), industrial ($49 billion), automotive ($38 billion), consumer ($40 billion) and chip cards ($3.3 billion). Automotive and industrial are forecast to grow at the highest rate, driven by electrification and automation of vehicles, digitalisation of industry, and electrical power grids

[152] IBIS World (2010) divides the industry into five major markets: communications equipment manufacturers; industrial firms; computer and peripheral equipment manufacturers; consumer electrical goods manufacturers; and solar panel manufacturers:

[153] IHS Markit, Technology Group, Worldwide Semiconductor Shipment forecast March 2018.

[154] EURIPIDES, https://www.euripides-eureka.eu/

Figure 57 Semiconductor industry by segment – 2017 market size and CAGR 2017-22



Source: Boosting Electronics Value Chains in Europe, A Report to Commissioner Gabriel (EC, 2018)

Note: (1) Market size in calendar year 2017; (2) Based on or includes content supplied by IHS Markit, Technology Group, Worldwide Semiconductor Shipment forecast March 2018.

Supply chains for electronic components go from materials and equipment, through design, chip production and systems integration, to end-product. They tend to be global, with materials, components and products imported and exported multiple times. Many companies operate a 'just-in-time' model, working across factories and facilities (House of Commons Committee on Exiting the European Union, 2017 C).

The rate of technological change in the sector is high (House of Commons Committee on Exiting the European Union, 2017 C). Representatives of companies and research and technology organisations active in the industry have highlighted two notable disruptions to value chains in recent years (EC, 2018):

First, a pervasive digital transformation driven by rapid advances in artificial intelligence opening the door to autonomous mobility, machine learning for the next levels of robotics and other industrial use-cases, breakthroughs in personalised healthcare, (cyber)-security, and sustainable energy management.

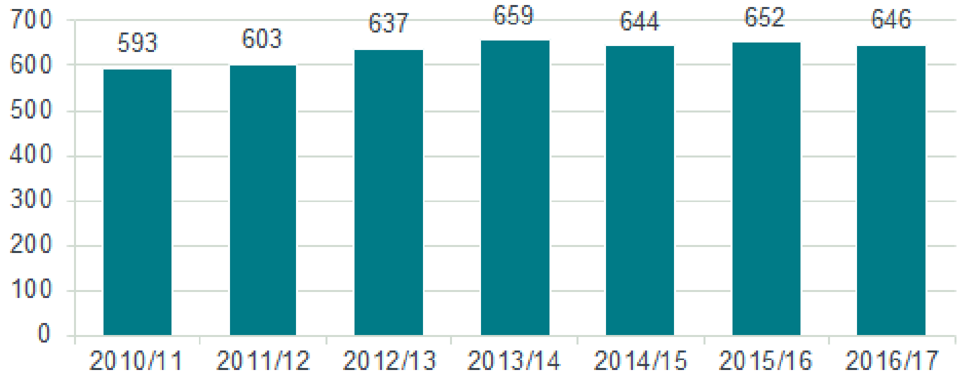
Second, the growing strategic importance of semiconductor components, coupled with the large investments in the advanced know-how and technology needed to produce them, has made them the object of a rapid succession of mergers and acquisitions and escalating levels of government support.

The rate of technological change means significant investments in capital and in R&D are needed. On the capital investment side, a new semiconductor manufacturing facility can cost £2 billion (and grows with each generation of products) (House of Commons Committee on Exiting the European Union, 2017 C). Around 15% of annual revenues are invested in manufacturing equipment and fabrication plants. Another 20% of revenues are invested in R&D. The key players of the electronics value chain in Europe invested around €13.6 billion in R&D between 2013 and 2017 (EC, 2018).

According to industry commentators (IBIS World, 2010), electronic component manufacturing has relatively high barriers to entry. The high level of investment required in capital and R&D can act as a barrier to entry. In addition, incumbent operators make use of IP rights including patents, which helps to insulate them from competing businesses profiting from their R&D activity.

As shown in Figure 58 and Figure 59, there were 646 UK electronic component companies in 2016/17, generating a total of £1.91 billion in revenue. However, the UK industry is not generally considered to be a global market leader and revenue growth lags behind global growth rates across the sector as a whole. According to IBIS World, some manufacturers have moved production abroad, which has weighed on industry revenue (IBIS World, 2010). This will not be the case across the entire sector and there will be pockets of UK competitive advantage in relation to specific activities. For example, the UK's world-leading researchers provide an excellent base for certain market segments. In addition, there is a world class semiconductor cluster in South Wales which includes a design studio, laboratories and test facilities.[155]

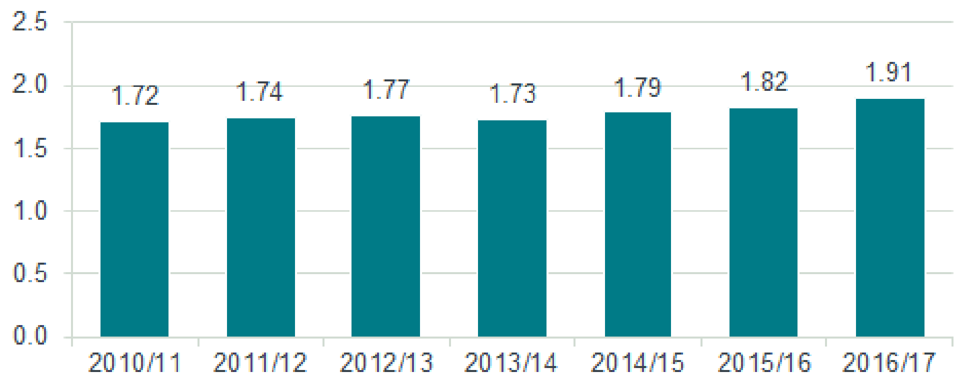
Figure 58 Number of businesses in manufacture of electrical components



Source: Frontier analysis of ONS data (Business Structure Database)

Note: (1) 2016/17 refers to the 2018 BSD publication. (2) Excludes enterprises with a legal status defined as public sector, central government, local authority or non-profits.

Figure 59 Turnover in manufacture of electrical components (£ billion)



Source: Frontier analysis of ONS data (Business Structure Database)

Note: (1) 2016/17 refers to the 2018 BSD publication. (2) Includes enterprises with a legal status defined as public sector, central government, local authority or non-profits.

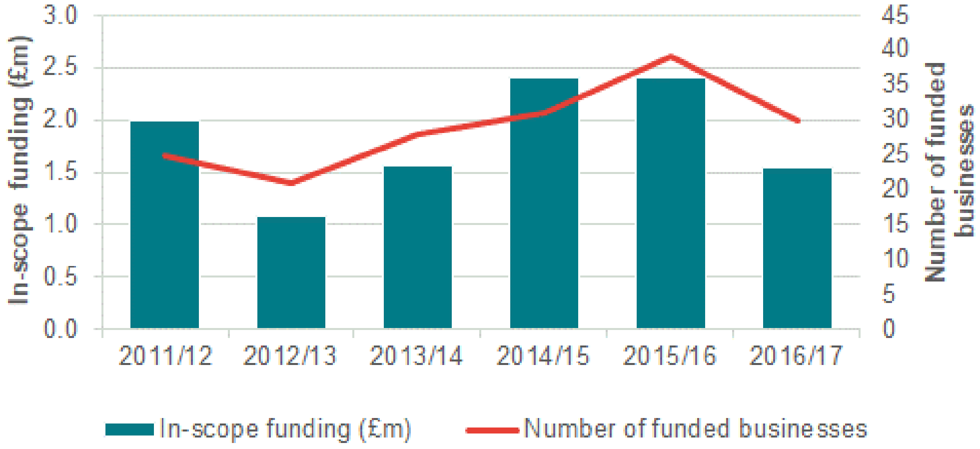
[155] https://csa.catapult.org.uk/wp-content/uploads/2018/07/Launching-the-Compound-Semiconductor-Applications-Catapult.pdf

Examples of companies operating in the UK under this SIC code range from large multi-national companies such as Siemens and Thales as well as specialist component providers such as TT electronics and Dynex.

7.5.2 Role of State aid

Figure 60 shows that between 2011/12 and 2016/17, IUK funded an average of 25 companies per year through the aid scheme, with total annual funding ranging from £1.1 million to £2.4 million.

Figure 60 In-scope funding and number of funded businesses in manufacture of electronic components



Source: Frontier analysis of IUK data and ONS data (Business Structure Database)

Note: (1) 2016/17 refers to the 2018 BSD publication. (2) Includes enterprises with a legal status defined as public sector, central government, local authority or non-profits.

Over 60% projects in this SIC code between 2011/12 and 2016/17 funded by the aid scheme were funded via the CR&D programme.

In addition to the activity which is in scope for our current evaluation, IUK also supports the sector via other mechanisms. For example, IUK has established the Compound Semiconductor Application Catapult in an effort to 'deliver long-term benefits to the UK economy and accelerate UK economic growth in industries where applying compound semiconductors creates a competitive advantage and enables new products or end markets' (IUK, 2018 B). The Engineering and Physical Sciences Research Council in the UK has also invested £750 million into compound semiconductor research.

State aid in support of the manufacture of electronic components is common in other European countries. Examples include:

- The German Research Ministry's €350 million support to Forschungsfabrik Mikroelektronik Deutschland (April 2017); and
- The Prime Minister of France's announcement of €800 million support for a total investment of €5 billion from industry for the five-year programme Nano2022 (EC, 2018).

Figure 61 provides some examples of projects funded by IUK in 2015/16.

Figure 61 Project examples for manufacture of electrical components (2015/16)

Project title	Recipient company	Aid intensity	Total funding committed
Multifunctional Integrated Microsystem for rapid point-of-care TB Identification	epigem	60%	£530,760
Security Tags Enabled by Near Field Communications United with Robust Electronics	FlexEnable Truly flexible electronics	60%	£189,972
Frequent Integrated Soft Stop Start Technology	DYNEX	40%	£326,046
Wing Integrated Systems Technologies	TE connectivity	50%	£615,475
Guide Cardiac Resynchronisation Therapy	SIEMENS Ingenuity for life	50%	£226,538
Ultra-thin Integrated Thin-Film Electronics Devices	PragmatIC	45%	£250,019

Source: *Frontier analysis of IUK data and ONS data (Business Structure Database)*

7.5.3 Hypotheses

Our hypotheses for the manufacture of electronic components sector follow from our overview of the market above.

Given the rapid technology change and strong need for investment in R&D for most players, our first hypothesis focuses on the potential for the aid scheme to distort competition in the market if it funds successful R&D and this results in a new electronic component that displaces the sales or negatively impacts the incentives of incumbent component manufacturers.

Similarly, our second hypothesis arises due to the nature of R&D competition in the electronic components sector and the importance of funding for investment in R&D. It considers whether funding from the aid scheme could give recipients an advantage in the race to develop new electronic components or crowds out other related R&D.

In addition, given the international nature of the sector with high trade intensity and global supply chains, our third hypothesis considers whether the aid scheme could distort the incentives of potential recipients by encouraging them to locate in the UK and/or conduct a greater proportion of their R&D in the UK. This is in keeping with the location effect result indicator which features in the EC's Common Methodology for State Evaluation (2014, A).[156] [157]

MANUFACTURE OF ELECTRICAL COMPONENTS – HYPOTHESIS #1

The aid awarded by IUK allows firms to undertake additional R&D which in certain cases leads to the development of new electrical components, which in turn causes harm to incumbent firms or distorts their incentives

[156] See Annex II p 36.

[157] This hypothesis will be assessed at a relatively high level as the scheme is not regional aid.

MANUFACTURE OF ELECTRICAL COMPONENTS – HYPOTHESIS #2

The aid awarded allows successful firms to undertake additional R&D, which gives them an edge relative to other firms seeking to carry out R&D in the race to develop an electrical component

MANUFACTURE OF ELECTRICAL COMPONENTS – HYPOTHESIS #3

The aid has encouraged recipients to locate in the UK or carry out R&D in the UK

8 INDIRECT IMPACTS ON COMPETITION: R&D ON BIOTECHNOLOGY AND MANUFACTURE OF MEDICAL & DENTAL DEVICES

This chapter assesses how Innovate UK (IUK) aid has impacted the R&D on biotechnology and manufacture of medical and dental instruments markets. As we described in Section 7.3 we are reporting the results of these two markets together as there are commonalities in terms of the underlying competitive structure. In addition, the R&D process plays a similar role in both sectors and firms in both markets apply for the same IUK funding competitions. Throughout this section we will note areas where the underlying evidence varies across the markets or our conclusions differ.

This chapter therefore assesses whether the IUK aid has been detrimental to either sector by testing the hypotheses we developed. We test these hypotheses using a mixed-methods approach and utilise an array of evidence, including analysis of IUK monitoring data and secondary datasets, stakeholder interviews and market reports.

8.1 Hypotheses testing

8.1.1 Hypothesis #1: The aid awarded by IUK allows firms to undertake additional R&D which in certain cases leads to the development of a new drug, or medical device, which in turn causes harm to the incumbent firms or distorts their incentives

CONCLUSION

The aid awarded by IUK supports projects that are inherently risky and therefore does not necessarily translate into commercial success for beneficiaries. Even if the project were to lead to a commercially successful drug or device, IUK funding does not support the final stages of development so the aid cannot guarantee that a new drug/device will reach market. This minimises the negative incentive effects that could apply to other market participants and reduces the likelihood of the aid being a direct source of harm to incumbents.

The chance of success for a given drug or medical device is low

Research and development is an essential part of the drug discovery process. The process is long and expensive, particularly due to the stringent regulatory barriers that exist to ensure that a new drug is safe.

As described in Section 7.2, the life-cycle of a new medicine involves several distinct stages before a new drug is brought to market. This process is long (12-13 years will have elapsed since the first synthesis of the new active substance)[158] and expensive (recent estimates presented by the European Commission (EC) suggest that the costs of bringing a medicine from the lab to market are between €0.5 billion and €2.2 billion) (EC, 2019).

Unsurprisingly, this process is highly risky – only a small minority of candidate molecules survive the development stage and finally make it to the market. Of 10,000 candidate molecules originally examined in the lab, perhaps 250 might make it to pre-clinical trials, ten might make it to clinical trials and one might have successful clinical trials and receive regulatory approval (EC, 2019). A US-based study examined the progress of drugs which had already reached Phase 1 testing. The authors concluded that even at this relatively advanced stage only 13.8% of all drug development programmes eventually lead to approval (Wong et al., 2019). It should also be noted that the success rate will vary considerably across the sector as it is heavily dependent on the disease or illness that the drug is targeting.

As we described in Section 7.5, the medical device industry has its own regulatory system, which has similarities with drug development rules. However, R&D time is generally shorter for medical devices given that physics is more predictable than chemistry. In addition, regulatory approval for medical devices tends to be quicker.[159] However, all stakeholders we engaged with in the medical device sector noted the high levels of risk involved, which is in keeping with the IUK ambition to fund high-risk projects that may not be pursued otherwise.

One stakeholder from the biotechnology sector told us that that they had initially started researching nine different compounds and eight had already failed while the ninth was undergoing further testing. Further risk exists even after testing is complete. One stakeholder from the medical instrument sector noted that clinicians are often reluctant to change protocol, even if a new product offers additional benefits.

Stakeholders indicated that the low chances of success in the drug and medical instrument development processes can result in challenging commercial funding environments. Specifically, stakeholders told us that it can be very difficult for start-ups to raise finance to get from an initial feasibility stage to a level of development where they can attract extra investment. Market participants commented that the largest pharmaceutical firms are looking for de-risked drugs and technologies that are already relatively close to market before investing.

This is consistent with the view of the EC. They find that innovation in biological drug development is shifting from big pharma companies to smaller players. While big companies continue to invest heavily in clinical trials and bring innovation to the market, today core innovation is increasingly generated by SMEs (EC, 2019).

As set out in the evaluation plan (EC, 2015 A),[160] we analysed the distribution of funded firms by size in the biotechnology and medical devices sectors (Figure 62,

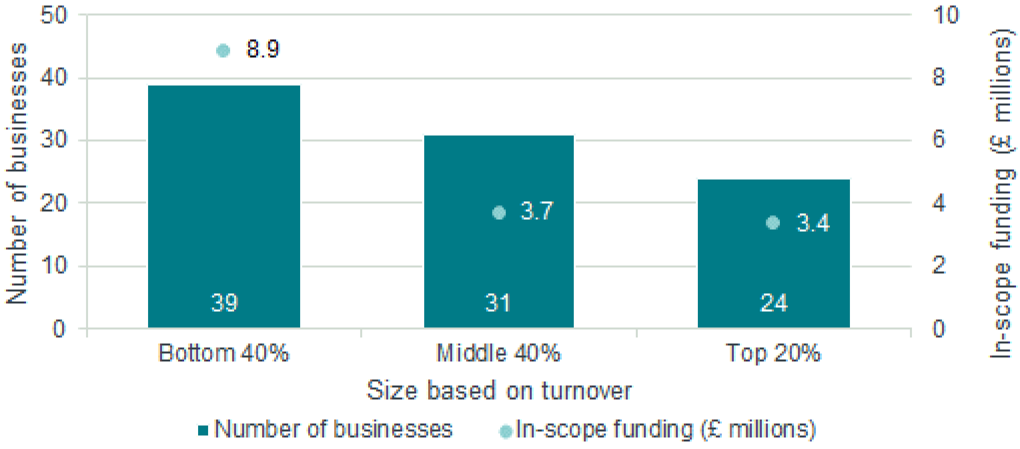
[158] European Federation of Pharmaceutical Industries and Associations.

[159] Timelines for the medical device registration process can vary depending on the class of the device. For Class I devices, the registration process typically takes no more than one week. For higher classes, the timeline is dependent on product type and contract with a notified body.

[160] See p 3, https://ec.europa.eu/competition/state_aid/cases/256732/256732_1703219_80_2.pdf

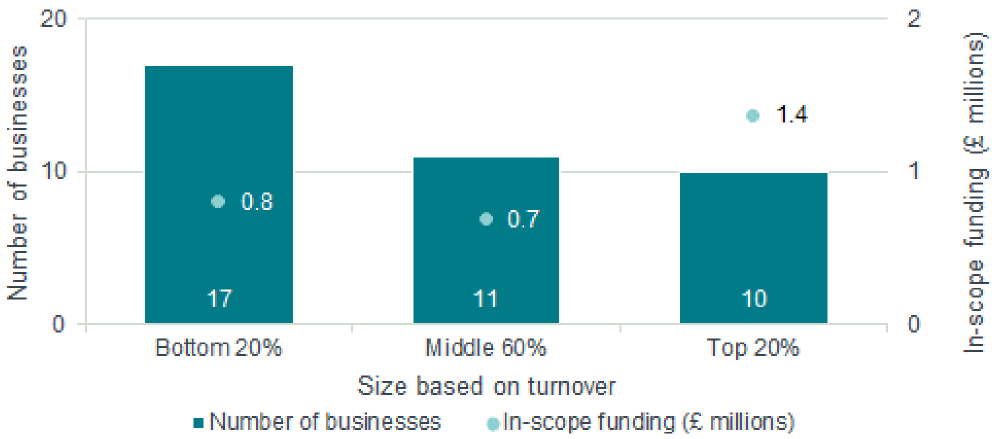
Figure 63). In both cases, the most common group of beneficiary firms were in the bottom half of the turnover distribution..

Figure 62 R&D on biotechnology, IUK beneficiaries by size (2015/16)



Source: Frontier analysis of the BSD

Figure 63 Manufacture of medical and dental instruments, IUK beneficiaries by size (2015/16)



Source: Frontier analysis of the BSD

IUK aid will, in certain circumstances, help to reduce the development risks inherent in these sectors. For example our analysis of BSD data shows that, on average, firms funded in 2012/13 in the medical and dental sector appear to be more likely to remain in the market than unfunded firms in the most recent available year of data. Of businesses that were funded in 2012/13, all funded businesses survived until 2016/17 whereas only 78% of unfunded business did (results are similar for biotechnology but cannot be displayed for confidentiality reasons). This analysis should be thought of as illustrative rather than causal. Econometric matching techniques have not been used in this case as funded firms are likely to differ from unfunded firms in a number of unobservable ways. However, the descriptive analysis does suggest that the IUK aid could be helping recipients to remain in the market for longer. This may be due in part to the funded firms overcoming the risks we describe above.

IUK funding will support a range of different biotechnology and medical device projects; some of these will be successful whereas others will not. This significant level of risk and uncertainty will mean that other non-supported firms active in the market will be unlikely to materially alter their behaviour as a result of IUK support. If IUK projects were guaranteed to reach market, the potential for negative incentive effects would be much higher.

IUK funding is not sufficient to get a drug/device to market

IUK funding is not targeted at the final stages of development when a drug or device is relatively close to commercialisation. Instead, IUK aid which is awarded to firms in these markets tends to be far removed from commercialisation, which according to EC (2014 C) guidelines means that it is less liable to crowd out other R&D.[161]

We were told by stakeholders in the biotechnology and medical device sectors that their projects with IUK were pre-clinical or at the initial clinical testing phase. Multiple stakeholders emphasised that IUK aid is not sufficient to support large-scale clinical trials, which are much more expensive due to their scale. For example, one firm we spoke to reported raising £40 million to date for development of their medical device. However, the product is yet to reach market and they are aiming to raise another £20 million to fund a clinical trial. The largest possible award under the Biomedical Catalyst programme is £4 million.[162] This is clearly insufficient to carry out the scale of testing required. We showed in Section 7.2 that Phase III clinical testing (which IUK aid does not cover) accounts for the largest share of pharmaceutical R&D investments.

These reflections from stakeholders are very much in keeping with our quantitative analysis which compares the IUK funding to all R&D expenditure across the sector as a whole in the UK. We show in the chart below that combined IUK funding to the biotechnology and medical devices sectors is less than 5% of total UK investment in pharmaceutical R&D in every year.[163]

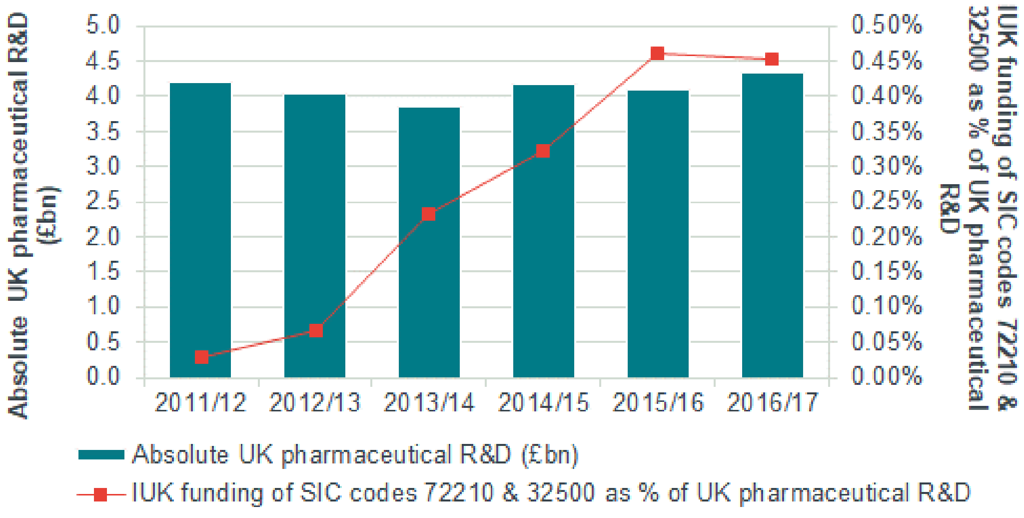
This provides further evidence that while IUK funding is very important to individual beneficiary firms it does not constitute a large share of total R&D investment and alternative funding sources will be needed to bring a new drug/device to market (Figure 64).

[161] EC guidelines refer to a number of factors which are discussed throughout this chapter. See p 24, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XC0627(01)&from=EN

[162] Our analysis of the aid scheme in Chapter 2 shows that the average award is considerably less than this.

[163] Pharmaceutical R&D was the most relevant category from the UK Business Enterprise Research and Development dataset.

Figure 64 IUK funding as % of total UK pharmaceutical R&D



Source: Frontier Analysis of UK Business Enterprise Research and Development dataset

Note: IUK aid awarded to firms in the biotechnology and medical devices SIC codes is compared to total UK investment in pharmaceutical R&D.

It is theoretically possible that IUK aid given to one firm could affect the commercial viability or the behaviour of an incumbent firm who is already manufacturing a similar drug or medical device. The incumbent firm could cease its own R&D efforts or lose market share as its sales are cannibalised. The likelihood of this happening is low.

In many cases, IUK-supported projects seek to open up new markets where current activity is limited

The reason the likelihood is low is because many of the projects funded by IUK are focused on the development of new drugs or medical devices that seek to address an entirely unmet need. Stakeholders emphasised the relatively limited range of conditions where truly effective therapies or cures exist. As a result, there is a huge disease burden where no treatments are available, and stakeholders felt that generally new drugs/devices were seeking to do something different to address these unmet clinical needs. This is in keeping with the objective of EU legislation introduced in 2000 to provide incentives for the development of medicines for rare diseases (so-called orphan medicinal products) (EC, 2010 B).

In these cases, there will be no incumbent firm so the specific distortion that we are considering here is not relevant. Furthermore, in these cases, the size and diversity of demand may imply that the successful firm is unlikely to serve all of the demand for a long period of time (depending on IP restrictions). Specifically, other firms will seek to compete by developing their own drugs or devices wherever possible. This implies that IUK aid could, in fact, indirectly stimulate additional R&D activity.

A number of stakeholders we engaged with reported that they used IUK aid to develop novel treatments not currently available elsewhere. If these products were successful there would be no incumbent firms who could be damaged. For example, one biotechnology company we engaged with is seeking to develop a treatment which addresses specific symptoms of a chronic disease which are not currently treated by existing drugs. This drug is therefore not a substitute for other existing drugs. Furthermore, a medical device company told us that they used IUK funding to develop an early-warning system for disease diagnosis. If this product reached the market, it would not remove the need to carry out currently available tests; instead, it would speed up the determination of whether tests were necessary. This technology could therefore be complementary to that provided by incumbent firms providing the full suite of tests. In other cases, IUK projects may affect incumbents, but the impacts are likely to be small and need to be considered holistically

Some of the projects funded by IUK seek to improve on existing treatments or technologies already available. In these circumstances, there may be a detrimental impact on incumbent firms if the project is successful. For example, a biotechnology company we interviewed received IUK support to develop a more effective treatment for a specific disease where numerous treatments already exist. If successful, the new product would be in competition with these existing products. Another medical device company used IUK funding to expedite diagnosis of a specific condition, which could mean that existing testing procedures that are supplied by other firms are no longer used.

This means that distortions are possible in the form of commercial damage to incumbent firms or alterations to their incentives. However, as noted above, the distance of the aid from the market and the relatively small magnitude of IUK funding means that even in these cases establishing a causal link to IUK would be difficult.

Furthermore, stakeholders noted that in some cases where an incumbent did exist, the existing firm might be a large pharmaceutical organisation who would have enjoyed significant revenue streams from existing products (now under threat) and could have undertaken its own R&D to improve the drug/device. It could also be the case that the incumbent firm actually decides to purchase the new drug or device and can then share in the benefits from the subsequent commercialisation.

Finally, stakeholders noted that any diversion of an incumbent firm's sales will be counterbalanced by benefits to consumers arising from new and improved products.

8.1.2 Hypothesis #2: Aid gives beneficiaries an artificial edge relative to other firms seeking to carry out R&D in the race to develop a new medicine/device

CONCLUSION

IUK aid may in some highly specific circumstances confer an advantage on recipient firms, which distorts competition, but the evidence suggests that these cases are likely to be extremely rare as the final market for supply of specific drugs or devices may be characterised by multiple players and the demand for medical devices and drugs will continue to grow.

The firm supported by IUK may be the only firm in the race

It is important to consider the effects of IUK aid on non-supported firms who are also carrying out similar R&D in the medical devices or biotechnology sectors or are considering carrying out related R&D in the future.

In stakeholder interviews, many of the recipient companies we engaged with noted that IUK allowed them to carry out research in a new area which would not have been possible without IUK funding. Furthermore, some stakeholders noted that there were no other firms they were aware of that were currently tackling the same issue.

One specific stakeholder noted that they were operating in a 'market of one' and currently no other firms were carrying out research on the same precise topic. Another stakeholder noted that there had been no major breakthroughs in their specific treatment area for the last '40 years'. In these cases, there will be no possible negative incentive effects on firms racing to achieve the same outcome, as these firms do not exist.

This is consistent with the EC's Framework for State Aid for Research and Development and Innovation (EC, 2014 C), which clarifies that the likelihood of distorted incentives is diminished where product innovation is about developing differentiated products. [164]

The magnitude of distortions depends on market characteristics. The nature of competition in the biotechnology and medical devices sectors suggests that significant concerns are unlikely

It is theoretically possible that the direct effects of the aid constitute an unfair advantage. This could in turn crowd out other beneficial research or allow the supported firm to reach market artificially ahead of other firm(s) and maintain that position for a sustained period of time. This could ultimately harm consumers if the supported firm's product is of lower quality than the product that would have been developed by non-supported firms if the aid had not been awarded.

[164] See p 24, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XC0627(01)&from=EN

The likelihood of these distortions occurring in practice depends on the underlying market dynamics and structure. We summarise relevant market characteristics for both the medical devices and the biotechnology markets in Figure 65 below.

Our engagement with stakeholders, desk research and quantitative analysis generally suggests that the features of these two sectors do not pose significant competition issues in the current context. However, there are specific issues which may be worth further consideration. Further detail is provided below.

Figure 65 Assessment of market characteristics on the distortion of competition from the IUK aid

Market/aid characteristic	Competition implication
The final market for supply of specific drugs or devices may be characterised by multiple players.	Reduces concerns
The demand for medical devices and drugs will continue to grow as the population ages.	Reduces concerns
Demand for drugs and medical devices across the UK/EU may be concentrated in a relatively small number of buyers.	Increases concerns
IUK aid to the life sciences sector is small relative to total R&D.	Reduces concerns
The IUK scheme does not pre-determine who should receive aid but relies on a competitive application process.	Reduces concerns

Source: Frontier

The final markets for supply of drugs and devices will generally be characterised by multiple players

The EC's Framework for State Aid for Research and Development and Innovation (EC, 2014 C)[165] notes that aid could result in non-funded firms halting their efforts to compete for a future 'winner-takes-all' market. Our stakeholder engagement suggests that, in general, specific clusters within the biotechnology or medical device markets will tend to be characterised by multiple firms rather than a single dominant player. Interviewees noted that there had not been significant consolidation across the biotechnology sector in recent years and that there were a range of treatment options (each underpinned by distinct but related IP) for specific conditions. Certain options will have their own pros and cons and therefore may be more or less suited to individual patients. This further minimises competition concerns.

For example, one of the medical device firms we interviewed told us that there were a small number of firms seeking to tackle the same issue they were looking

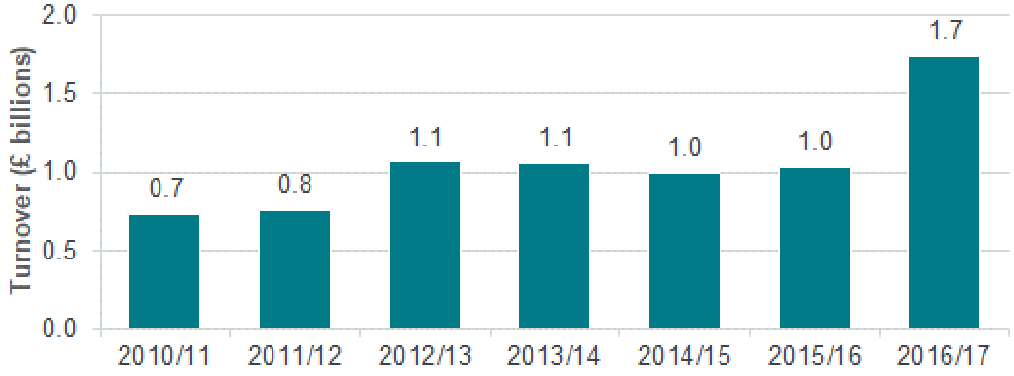
[165] See p 24, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XC0627(01)&from=EN

at and one firm already had a product on the market. This had not stopped them from carrying out their research.

Demand for medical devices and drugs will continue to grow as populations age

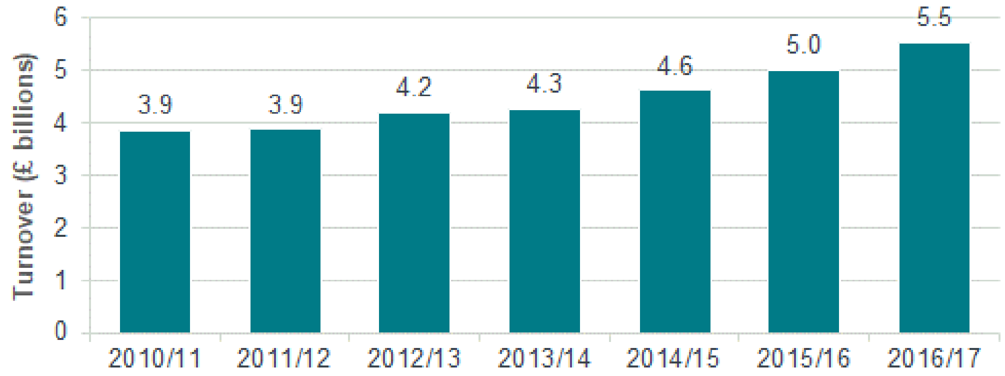
Stakeholders repeatedly emphasised that ageing populations mean that the demand for healthcare is likely to rise in the future. This is in keeping with our quantitative analysis. Firstly, our analysis of BSD data shows that total turnover in the biotechnology (Figure 66) and medical device markets (Figure 67) has increased in recent years.

Figure 66 Turnover growth in R&D in biotechnology market, 2010/11-2016/17



Source: Frontier analysis of the BSD

Figure 67 Turnover growth in medical and dental market, 2010/11-2016/17



Source: Frontier analysis of the BSD

Therefore, we can conclude that the markets have undergone significant growth in recent years and this growth is projected to continue. This minimises the rise of potential competition distortions as multiple new firms may be accommodated without exit (EC, 2014 C).[166] As a result, the likelihood of IUK aid crowding out other non-funded R&D is small.

[166] See p 23, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XC0627(01)&from=EN

Demand for drugs and medical devices across the UK/EU may be concentrated in a relatively small number of buyers

In the healthcare sector the final users of medical devices or drugs may not always make purchasing decisions for themselves. Often, purchases will be made on behalf of final consumers by medical professionals or healthcare providers. This may imply that demand is concentrated amongst a relatively small number of buyers.

This could marginally increase concerns. It is possible that the concentration of buyer power and the existence of procurement guidelines across national healthcare bodies increases the chance of a single dominant drug or device emerging within a specific market niche. However, we have not seen any evidence of this occurring in practice. In reality, as described above, even within the UK's single National Health Service there will be a large number of individuals making prescribing decisions. These decisions will be informed by the needs of individual patients, which will vary.

IUK aid to the life sciences sector is small relative to total R&D

As we described above, combined IUK funding to the biotechnology and medical devices sectors is less than 5% of total UK investment in pharmaceutical R&D in every year.[167]

This further reduces the possibility of the aid distorting incentives of competitors, as alternative funding sources will be available to bring a new drug/device to market.

The IUK scheme does not pre-determine who should receive aid but relies on a competitive application process

The risk of an IUK-supported firm developing a drug/device which is of lower quality than the alternative that would be developed by other firms in the absence of aid is mitigated by IUK's process for awarding funding. Stakeholders noted that the process for large awards is very robust and includes inputs from clinical experts who are best placed to judge the merits of a new drug/device.

This in in keeping with the EC's (2014 C)[168] Framework for State Aid for Research and Development and Innovation, which states that aid which is awarded on the basis of an open selection process which draws on transparent, objective and non-discriminatory criteria will be viewed more positively.

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[167] Pharmaceutical R&D was the most relevant category from the UK Business Enterprise Research and Development dataset

[168] See p 24, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XC0627(01)&from=EN

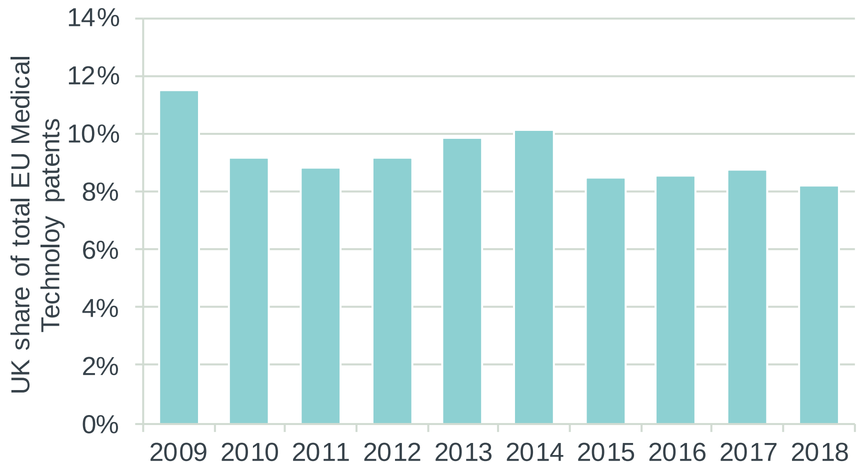
8.1.3 Hypothesis #3: Aid encourages recipients to locate in the UK or carry out R&D in the UK

CONCLUSION

The IUK aid scheme is non-discriminatory as any UK-based firm can apply. Biotechnology and medical technology firms' location decisions are driven by a multitude of factors which are generally unrelated to the funding provided by IUK, such as the availability of skilled employees.

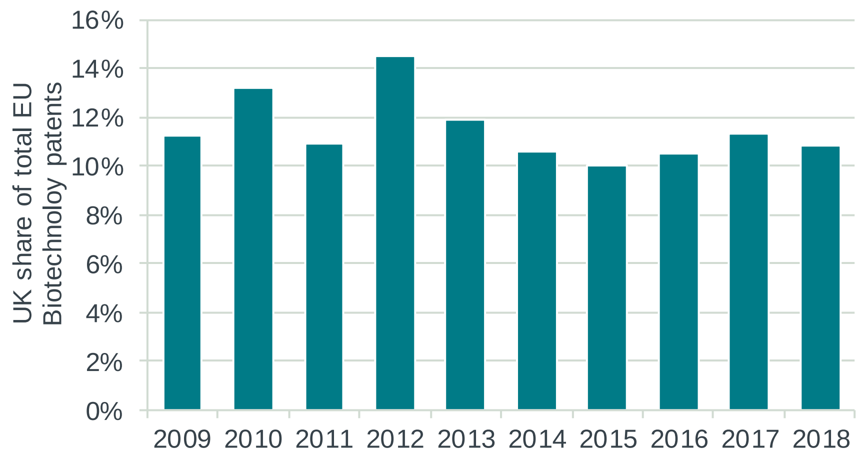
The UK medical device and biotechnology sectors are strong and have been for many years. As can be seen below, the UK accounts for a significant (and broadly constant) share of EU medical devices (Figure 68) and biotechnology patents (Figure 69). Therefore, there is no evidence to suggest that recent IUK aid has shifted patent activity (which could be a proxy for successful R&D) to the UK away from other parts of the EU.

Figure 68 UK share of EU medical technology patents granted



Source: Frontier Analysis of EPO data

Figure 69 UK share of EU biotechnology patents granted



Source: Frontier Analysis of EPO data

Our qualitative engagement highlighted a number of comparative advantages for the UK. Specifically, firms highlighted the highly skilled workforce and world class scientific institutions as key points of difference. One stakeholder noted that the UK had a worldwide reputation for delivering quality. We were told that it is these factors that makes the UK an attractive location and not IUK funding.

Multiple stakeholders mentioned that the private funding environment is an important consideration in regard to location. One stakeholder commented that availability of private funding is far more important than grant funding, which was generally thought of as a secondary option. Stakeholders repeatedly emphasised that raising funding in the USA was easier than in Europe, due to a difference in risk appetites.

IUK aid, which funds a very small proportion of overall R&D activity, does not appear to be driving the location decision of firms in these sectors. Firms considering moving to the UK to take advantage of the IUK scheme also cannot rely on receiving IUK aid as each funded project requires the submission of a full application, which may be rejected. A potential applicant would have to locate in the UK first and then apply for funding.

9 INDIRECT IMPACTS OF COMPETITION: MANUFACTURE OF AIR AND SPACECRAFT AND RELATED MACHINERY

This chapter assesses how Innovate UK (IUK) aid has impacted the manufacture of air and spacecraft sector. Although we refer to IUK aid throughout this chapter, the majority of funding that is awarded to firms in this sector comes from the ATI/BEIS/Innovate programme.[169] In general, we focus on the impact of the aid on the development of large commercial aircraft (LCA) as this is where the majority of aid is focused.

We assess whether the IUK aid has had any negative indirect effects on this sector by testing the hypotheses we developed in Section 7.4. We test hypotheses using a mixed-methods approach and utilise an array of evidence, including analysis of the IUK monitoring data and secondary datasets, stakeholder interviews and market reports.

9.1 Hypotheses testing

9.1.1 Hypothesis #1: The aid has contributed to the increased market power of a single Original Equipment Manufacturer (OEM) at the top of the supply chain

CONCLUSION

It is highly improbable that IUK aid has led, or will lead to, a material increase in the market power of either Airbus or Boeing. IUK aid is insufficient in scale to create such a distortion. Moreover, it is available to any UK-based firm and applications are rigorously and independently assessed. Both OEMs may also benefit from the significant aid distributed to firms lower down the supply chain.

IUK aid does not favour a specific OEM

As we described in Section 7.4, the primes/OEMs are those firms at the top of the aerospace supply chain manufacturing whole aircraft. There are very few full body manufacturers of large commercial jets operating globally. Competition at the prime level between Airbus and Boeing has therefore been characterised as a duopoly.[170] This consolidation has been driven by a series of mergers (Competition Policy International, 2019).

169 https://www.ati.org.uk/funding/research-technology-funding-opportunities/

170 https://www.cnbc.com/2019/01/25/why-the-airbus-boeing-companies-dominate-99percent-of-the-large-plane-market.html

Given that Boeing and Airbus have high market shares at the top of the supply chain, it is theoretically possible that IUK aid could contribute to the dominance of either of these firms at the top of the supply chain.

Our analysis shows, however, that IUK aid does not favour any individual firm over another. As part of our qualitative research, we interviewed firms who had successfully applied for IUK funding. These firms noted that they had also had funding applications rejected on a number of occasions. This implies that the awarding process is rigorous and that each application to the programme is judged individually on its merits rather than simply pre-determining which firms should receive aid.

Specifically, each application is subject to a rigorous multi-stage assessment whereby different organisations provide a separate review (ATI, 2018 A):

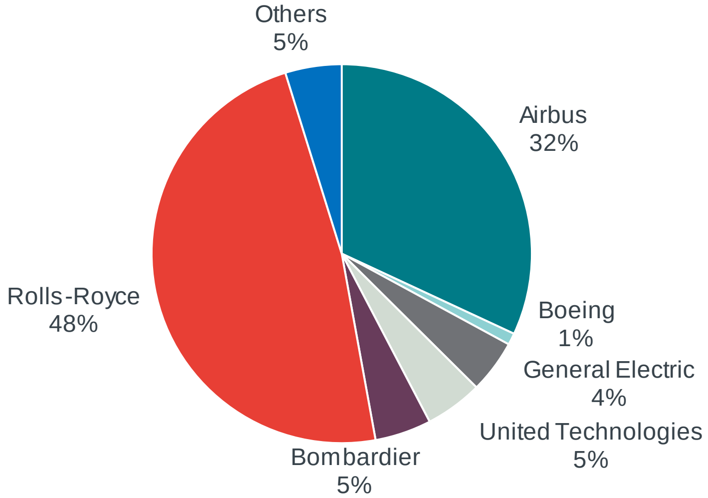
- **IUK's** assessment involves scrutiny from an independent panel of experts with recognised technical and business skills to review the detailed project proposal that has been submitted.
- **Department for Business, Energy & Industrial Strategy's (BEIS)** assessment involves exploration of the potential impacts of post-project exploitation, commercialisation and use of the technology as well as a value-for-money assessment based on the cost of the project.
- **Aerospace Technology Institute's (ATI)** strategic assessment considers alignment to the UK Aerospace Technology Strategy, fit with existing activity and the capability of project partners.

The EC's (2014 C)[171] Framework for State Aid for Research and Development and Innovation states that aid which is awarded on the basis of an open selection process which draws on transparent, objective and non-discriminatory criteria will be viewed more positively. An independent process evaluation of ATI funding (Ipsos MORI, 2017 C) concluded that the application process was considered appropriate, involving efforts that were deemed by applicants to be proportionate in relation to the level of funds involved.

Airbus has received significantly more funding than Boeing under the scheme. This is in line with the R&D activity of both Boeing and Airbus in the UK (Figure 70). The total aerospace R&D activities of Airbus conducted in the UK amounted to £353 million in 2016, making Airbus the second largest contributor after Rolls-Royce to UK aerospace R&D. In contrast to this, Boeing's R&D activities in the UK are considerably smaller at only £11 million (ATI, 2018 B).

[171] See p 24, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XC0627(01)&from=EN

Figure 70 Percentage of UK aerospace R&D in each of the top ten firms

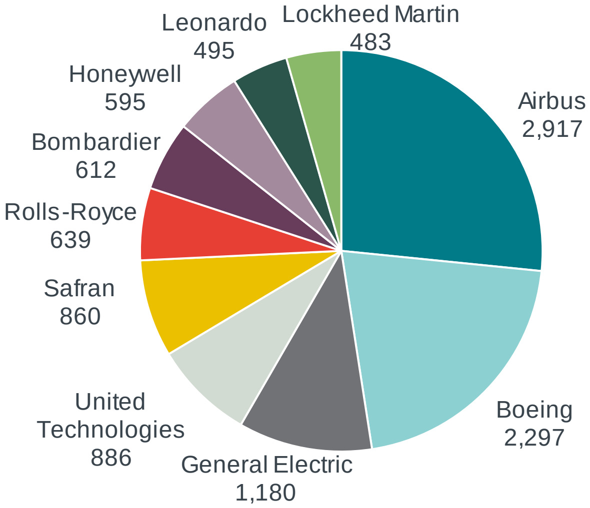


Source: Frontier Analysis of ATI (2018 B)

Note: Any firm lower than 5% (with the exception of Boeing) has been included in a group called Others for the purposes of the above chart.

Globally, the picture looks very different (Figure 71). Boeing also makes significant investment in R&D. This takes place in different geographical areas to Airbus. The large R&D investments made each year by both Airbus and Boeing, combined with their long history of operating in the aerospace sector, may constitute an exit barrier to the innovation process. The EC's Framework for State Aid for Research and Development and Innovation (EC, 2014 C)[172] notes that significant exit barriers mean that competitors are more likely to maintain or increase their investment plans when aid is awarded. This in turn reduces the likelihood of crowding out. [173]

Figure 71 Global aerospace R&D in the top ten companies, £ million (2016)



Source: Frontier Analysis of ATI (2018 B)

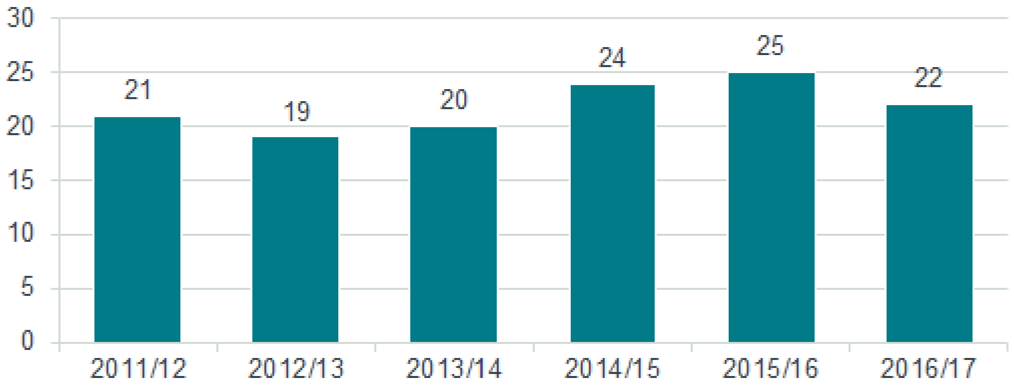
In addition to direct funding of the primes, IUK also funds firms at earlier stages of the supply chain. Firms active in this sector who we interviewed as part of our

[172] See p 24, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XC0627(01)&from=EN

[173] It is important to note that while exit barriers may lower the forward-looking costs of innovation but does not mean that the companies will not drop innovative projects if not profitable on their own.

qualitative research noted that Tier 1-3 firms can in some cases work with both of the major prime firms. Therefore, some IUK support of these non-prime firms can indirectly benefit both of the primes. We can see this from our analysis of IUK monitoring data. IUK consistently funds over 20 aerospace firms each year (Figure 72). Therefore, clearly IUK is funding firms at multiple different points of the supply chain.[174]

Figure 72 Number of firms in the aerospace industry funded by IUK, as defined in 2015/6



Source: Frontier Analysis of BSD

This includes firms who produce significant sections of the plane, known as Tier-1 firms, and those who produce more specific component parts that are then incorporated into the final design (Tier 2/3 firms).

The overall scale of the aid is relatively small

The magnitude of the IUK aid in the aerospace sector is small when compared to the overall scale of R&D activity taking place in the sector. In 2015/16, for example, our analysis of IUK monitoring data showed that they provided £71.7 million of in-scope funding to businesses in the *Manufacture of air and spacecraft* SIC code. We compared this to total UK R&D expenditure in 2016 (using UK Business Enterprise Research and Development data) and concluded that the IUK funding represents only 3.8% of the £1.9 billion of aerospace R&D.

The IUK aid figure of £71.7 million that we report is significantly lower than the £150 million per annum published by ATI, reflecting their commitment to provide £1.95 billion[175] in R&D grant funding over a 13-year horizon (2013/14-2025/26). This discrepancy is driven by differences in sample, timeframe and definition.[176]

[174] Importantly, IUK is also funding firms to carry out aerospace R&D who are not classified in the *Manufacture of aerospace* SIC code as they are also active in other sectors (such as the manufacture of automobiles). The numbers reported in Figure 72 will not include these firms.

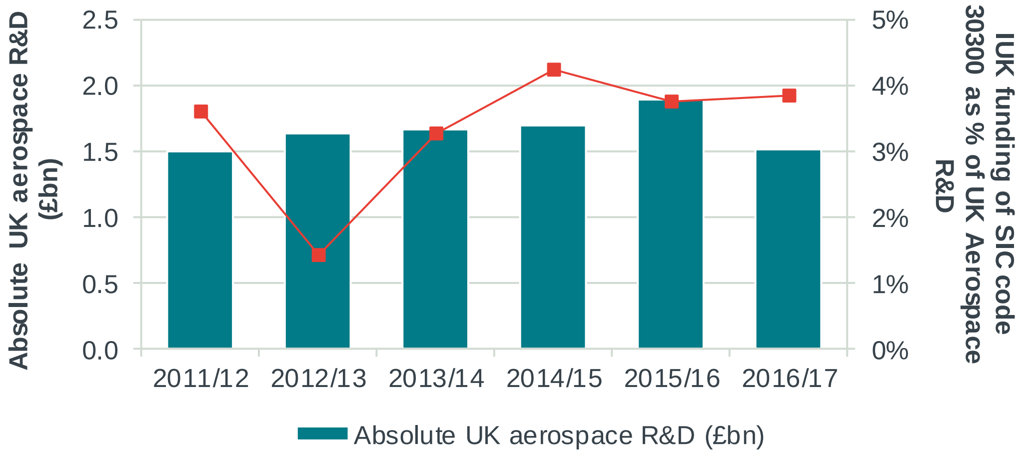
[175] ATI Monthly Portfolio Statistics for the UK Aerospace R&T Programme, August 2019 https://www.ati.org.uk/resources/portfolio-statistics/

[176] Differences between IUK and ATI figures:

- A primary difference between the two figures is that the £71.7 million only refers to IUK funding received by firms within the *Manufacture of air and spacecraft* SIC code. This therefore misses the important presence of non-SIC code firms who are heavily active in the sector, which the ATI figure of £150 million per annum considers. For example, as seen in Figure 70, Rolls-Royce is the largest investor in UK aerospace R&D, and as outlined in ATI's details of collaborative R&D project case studies a large recipient of aid. However, since the firm is not in the *Aerospace* SIC

Importantly, the overall magnitude of the aid is still relatively small regardless of which figure is used and has declined slightly in recent years as a proportion of overall R&D.

Figure 73 IUK funding as % of UK aerospace R&D



Source: *Frontier Analysis of IUK monitoring data and UK Business Enterprise Research and Development data*

9.1.2 Hypothesis #2: The aid may allow a recipient firm to artificially guarantee itself a place in future supply chains at the expense of rivals

CONCLUSION

Collaboration is an essential part of the R&D process in this sector. The IUK aid facilitates this. Given the complexity of supply chains and the length of development cycles, large firms will invest in multiple competing R&D projects to mitigate risk. It is highly uncertain which will be successful. This implies that a specific IUK-supported project is not guaranteed to produce commercial outcomes for beneficiary firms seeking to enter the supply chain. Even if a funded project was successful there is no guarantee that the collaborators would be the sole suppliers of the new component to the OEMs because of the emphasis on dual sourcing.

code, the value of their IUK projects and their aerospace R&D are missed from the statistics in Figure 73.

- The ATI figure, £150 million, is a predicted average across the 13 years of the project using a simple average of the goal amount of £1.95 million (£1.95 billion/13 = £150 million).
- This average is not only forward looking (2013/14-2025/16), it also refers to years outside the scope of this assessment.
- Around 30% of the ATI figure refers to grants awarded to research/academic organisations, such as universities and Catapults, whereas the £71.7 million calculated only refers to private firms.
- Lastly, the figure quoted in the ATI portfolio report refers to grant commitments. This is contrary to the figures used in the £71.7 million which refer to funding which has already been distributed.

Therefore, given these discrepancies, it is unsurprising that the figure provided by ATI differs greatly from the figure used in our analysis.

Collaboration is an essential part of the R&D process for all firms in this sector. The IUK aid offers collaboration opportunities

Stakeholders noted that collaboration was an essential part of the R&D process for all firms in the LCA sub-sector. We were told that bringing together all of the required components for a commercial aircraft is incredibly complex and new firms operating below the OEMs need to work with the primes to ensure that their R&D coincides with the overall development cycle.

This collaboration generally occurs between relatively large firms. A small number of larger firms account for the majority of investment in R&D. It is therefore no surprise that our analysis of IUK monitoring data shows that that 90% of IUK funding to the aerospace SIC code goes to the top ten largest businesses. Unsurprisingly, given that the aid usually supports the larger firms in the sector, we also found that the IUK aid is significantly more likely to be awarded to older firms in this sector. This is in keeping with the results of a process evaluation of the BEIS/IUK/ATI sub-programme. The authors concluded that the programme appears to have been effective in engaging the most economically and technologically significant organisations in the aerospace sector. However, few applications have been received by SME-led consortia (Ipsos MORI, 2017 C).

In the EC's Common Methodology for State Evaluation (EC, 2014 A) the proportion of old versus young firms is included as a possible result indicator for negative indirect impacts of the aid scheme.[177] We find that that the median age of funded firms in 2015/16 was 31 years while the equivalent figure for unfunded firms was only five years. This is probably because younger firms are far less likely to be involved in the LCA sub-sector where IUK activity is concentrated.

The ATI/BEIS/IUK-funded programmes are often collaborative projects involving multiple stakeholders. According to data provided by ATI, the average number of partners in an ATI-funded project is four, with the majority of projects involving between two and five partners (ATI, 2018 B). Our review of IUK monitoring data revealed that these projects often involve collaboration between private business and research institutions. This sort of cooperation between private and public is included in the EC's Common Methodology for State Aid Evaluation as a potentially positive indirect effect of an aid scheme (EC, 2014 A).[178] The complexity of commercial aircraft design makes this significant level of collaboration essential to bring a new product to market.

Our qualitative research indicated that these collaborative arrangements were generally highly valued, for example, by allowing Tier 1 and Tier 2 firms to better understand OEM priorities.

The IUK aid may not lead to commercial outcomes

Firms at the top of the supply chain may invest in multiple R&D projects in the same area to mitigate risk. It is highly uncertain which of these will be successful. Some of these may be IUK funded while the majority will be self-funded. Ultimately, one

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177 See p 38, https://ec.europa.eu/competition/state_aid/modernisation/state_aid_evaluation_methodology_en.pdf.

178 See p 38, https://ec.europa.eu/competition/state_aid/modernisation/state_aid_evaluation_methodology_en.pdf.

of these projects may be taken forward and brought to market but there are no guarantees that this will be the IUK-funded project.

The IUK aid is for projects that are risky and not close to the market. Stakeholders who we interviewed stated most of the funded projects were seeking to reach market by around 2025-2030 (ATI, 2018 B). This long lead time on aerospace design and manufacture has been increasing, with ATI reporting that the length of time between new civil aviation programmes increased from around eight years in the 1960s/80s to 12 years in the 2000s (ATI, 2018 B).

Stakeholders who had received IUK funding in this sector agreed that the route to market is very long and indicated that their IUK projects may be a decade away from entering service.

From a State aid perspective, the further away from the market an intervention is, the smaller the incentive effects are for the firms alone to invest in R&D. This closeness to market is stated in the EC (2014 C)[179] guidelines as a key factor. Similarly, following an investigation of other sources of State aid (outside the scope of this evaluation) awarded to Airbus, the WTO (2010, 2011) concluded that subsidies focused on R&D were less of a concern than other subsidies as they were pro-competitive.[180]

In our stakeholder interviews, we were told that IUK projects may contain a level of risk that is too high for commercial companies to undertake without the support of IUK. Therefore, the IUK aid could be pro-competitive as it increases the range of projects being carried out in the same specific area.

The aid provides no guarantee of place in the supply chain even if it is successful

While the collaborative relationships we describe above are beneficial during the project, there is no guarantee that a successful R&D project will lead to collaborators enjoying a 'preferred supplier' position on an on-going basis. Multiple stakeholders emphasised that the IUK projects did not ensure that future commercial relationships will persist as larger firms at the top of the supply chain place an importance on the ability to multi-source every possible component.

It is therefore unlikely that the IUK aid artificially guarantees partner firms at lower levels of the supply chain an on-going position in the future.

179 See p 24, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XC0627(01)&from=EN

180 This WTO dispute related to EU vs. US competition, and a detailed exploration of the findings was outside of the scope of our work. The WTO concluded that 'the impact of pre-competitive R&TD subsidies on Airbus' market presence was perhaps more attenuated, compared with the other subsidies at issue'.

9.1.3 Hypothesis #3: Aid makes it more difficult for new firms to enter the industry and compete effectively

CONCLUSION

Upper tiers of the aerospace industry have high barriers to entry, making entry difficult, but this is fundamentally unrelated to IUK aid. The aid is also unlikely to affect entry of firms at other points of the supply chain where barriers are lower and the aid is less commonly awarded.

Entry into the upper levels of the supply chain is very difficult but this is unrelated to IUK State aid

The aerospace industry, particularly at higher levels of the supply chain, is characterised by high barriers to entry. This is a long-standing feature of the market and was evident prior to IUK funding. One stakeholder noted that knowledge and skills held by incumbents is an entry barrier as expertise develops over decades and cannot be easily replicated. This is in keeping with the way OEMs organise their R&D activity by country. For the last 50 years or more the UK has tended to focus on landing systems, wings and engines. Other European countries specialise elsewhere. For example, Airbus's propulsion integration capability is based in France. In addition to knowledge and expertise, stakeholders told us that the capital requirements to establish an aerospace manufacturing firm at the top of the supply chain are extremely large.

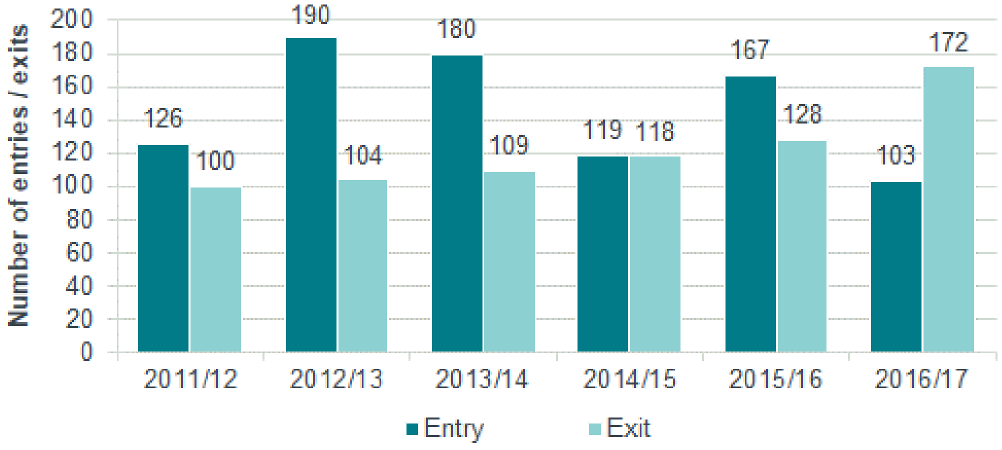
These market characteristics are unrelated to IUK's aid. Stakeholders indicated that the funding had not created or materially exacerbated these issues.

There is some significant entry in the UK of smaller firms

While entry into the prime and Tier 1 levels of aerospace manufacturing is very difficult for the reasons we mention above, entry into the lower levels of the supply chain seems to be more straightforward. IUK aid could improve the prospects for SMEs in the sector as it provides collaboration opportunities that may not otherwise exist.

Our analysis of the BSD (Figure 74) shows a significant amount of entry over time (over 100 firms every year entering the relevant SIC code). In addition, we found that entry exceeded exit in all years apart from 2016/17. It is not realistically possible that this is being driven by IUK aid but it is worth monitoring further in future years.

Figure 74 Number of entrants into the UK aerospace manufacturing SIC



Source: Frontier Analysis of the BSD

We carried out further analysis to explore the characteristics of these entrants. We found that, as expected, the new entrants are relatively small. The average turnover in 2016/17 of the largest ten new entrants from any time after 2011/12 was a little over £1 million, and the average employment was approximately 115 employees. The majority of new entrants were far smaller than this.

9.1.4 Hypothesis #4: The aid leaves profitable non-recipients at a competitive disadvantage, leading to exit. Or the aid allows unprofitable recipient firms to maintain an inefficient market presence

CONCLUSION

The size of the aid in contrast to the size of the large firms (both OEMs and other firms near the top of the supply chain) means that the IUK aid alone would not be enough to support large unprofitable companies. Those firms' current revenues derive from sales of existing aircraft rather than developing future models. Similarly, profitable non-recipients are unlikely to be left at a material competitive disadvantage.

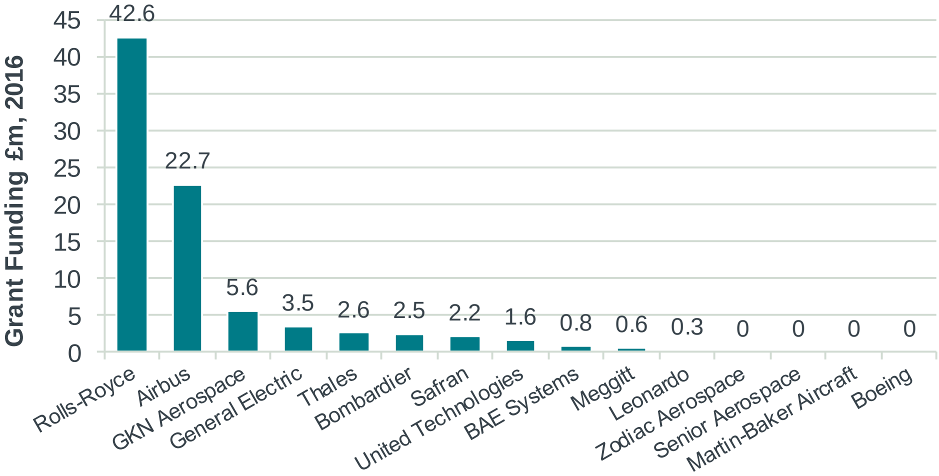
Aid has not placed successful non-funded firms at a competitive disadvantage

As we previously described, the projects funded by IUK are not close to the market. Therefore, the aid is less likely to distort trade or competition by negatively affecting competitors' incentives. Specifically, competitors are aware that IUK-funded projects will be characterised by a high degree of risk and therefore the likelihood of crowding out is minimised.

The aid does not put unfunded firms at a disadvantage by itself. Even if specific IUK projects are successful, firms who do not receive IUK funding can still respond by carrying out their own R&D long before the IUK projects reach market. There was no evidence provided in either stakeholder interviews or in the ATI analysis that firms exited as a result of support provided to competitors.

Our analysis shows that several of the largest UK aerospace firms did not receive IUK support (Figure 75) in 2016. This has not prevented these firms from carrying out R&D and continuing to operate successfully. It may be that their R&D work is located elsewhere or is not suited to IUK funding.

Figure 75 Aid Funding in 2016 for the Top 15 UK Aerospace firms (£ million)



Source: Frontier analysis of The Economics of Aerospace: The Evolving Aerospace R&D Landscape (ATI, 2018 B)

Finally, the stakeholders we interviewed noted that the market for commercial air travel is expected to grow quickly in the future. Specifically, between 2017 and 2036 the International Air Transport Association expects the number of passengers to double. This implies that there is significantly less risk of firm exit as multiple firms can co-exist to meet growing demand.

The aid will not impact current profitability of firms and is by itself not enough to sustain large companies

The IUK aid is geared towards the development of new aircraft. Any associated commercial impacts of this aid scheme will not be realised quickly. Therefore, current profitability and continued market presence are unrelated to current aid schemes.

It is possible that current market presence has been influenced by aid awarded previously outside of the current evaluation period. However, this is also highly unlikely because the magnitude of commercial aerospace R&D in the UK is much larger than the grants received by these firms.

The ATI grant funding is therefore only very small when compared to the total pool of R&D expenditure in 2016 that large companies such as Airbus (£353 million) and Rolls-Royce (£531 million) carried out. The IUK aid will not be sufficient to sustain these very large companies if they are becoming unprofitable as a result of external factors.

In addition, each funded project requires significant match funding. Our analysis of IUK monitoring data shows that the average aid intensity of typical IUK-funded projects in this sector is less than 50%. The firms therefore need to contribute their own revenue in order for the R&D to go ahead. This may not be possible for an unprofitable firm considering market exit.

It is theoretically possible that the aid could support some inefficiency in a smaller specific market within the overall sector where the aid is more material. It was not possible to assess this quantitatively within the current study. However, it was not raised as an issue by any of the stakeholders.

9.1.5 Hypothesis #5: The aid encourages recipients (both OEMs and other firms near the top of the supply chain) to locate in or carry out R&D in the UK

CONCLUSION

The IUK aid scheme is non-discriminatory as any UK-based firm can apply. Aerospace firms' location decisions are driven by a multitude of factors, such as patterns of historical expertise, which are generally unrelated to the funding provided by IUK.

Aerospace firms' location decisions are driven by a multitude of factors which are generally unrelated to funding provided by IUK

Our stakeholder engagement suggests that there are a relatively small number of countries who engage in the manufacture of large commercial aircraft.

The geographic location of certain types of activity is influenced by historical areas of expertise. For the last 50 years or more, the UK has tended to focus on landing systems, wings and engines. Other European countries specialise elsewhere. For example, Airbus's propulsion integration capability is based in France. Our review of the IUK monitoring data showed that numerous IUK projects support wing development (see project examples in Section 7.4).

These clusters of expertise will be an important factor in firms' location decisions and tend to be stable over time as firms develop skills and IP that can be deployed in future work. It would not make commercial sense for a firm to carry out a specific type of R&D in the UK where the underlying expertise was not available, even if support such as the IUK aid was available. In addition, as we present below, other EU countries also offer similar aerospace support programmes.

The larger firms funded by IUK tend to have activities across Europe, and sometimes globally. Airbus, for example, is active in R&D in France, Germany, Spain, Russia, Turkey, Finland and Romania.[181]

The ATI report noted that the major aerospace companies based in the UK are multi-nationals who are able to invest across the world (ATI, 2018 B). Therefore, large firms will not make a single location decision in regard to R&D. They will base

[181] https://www.airbus.com/company/worldwide-presence.html

activities in multiple countries and will take account of numerous factors such as skill and labour costs.

The ATI-BEIS-UK aid programme is in keeping with other EU members' activities

The IUK aid scheme is non-discriminatory as any UK-based firm can apply. Also, the IUK aid is in keeping with the support that other countries are providing to firms active in the aerospace sector, as can be seen in Figure 76 below. It should be noted, however, that this is not an exhaustive list. During our qualitative engagement, stakeholders indicated that the UK is not doing more than other countries, stating that they believe other European countries have similar levels of grant assistance, or run programmes of comparable size.

Figure 76 Example European programmes similar to ATI/BEIS/IUK

Programme	Country	Brief Summary
LuFo – Federal Aviation Research Programme	Germany	This programme supports Germany's international competitiveness by sponsoring R&D within the framework of the Aviation Research Programme of federal government. The funding takes the form of a grant. The level of funding amounts for up to 50% of the eligible costs for large enterprises, up to 65% of the eligible costs for SMEs and up to 100% for universities and non-university research institutions.[182]
BMWI – Federal Ministry for Economic Affairs & Energy	Germany	The BMWI is the government body responsible for the German aerospace industry and for any State aid in aircraft manufacturing. It has allocated €164.5 million[183] of their 2019 budget to R&D in the industry.
The Spanish Ministry of Industry, Energy and Tourism	Spain	The ministry operates an aerospace sector competitiveness fund, which can help finance up to 75% of the budget of a project that will develop a productive industrial activity in Spain in the sector.[184]

182 https://www.bmwi.de/Redaktion/EN/Publikationen/lufo-bmwi.pdf?__blob=publicationFile&v=3

183 https://www.bmwi.de/Redaktion/EN/Artikel/Ministry/budget-2019.html

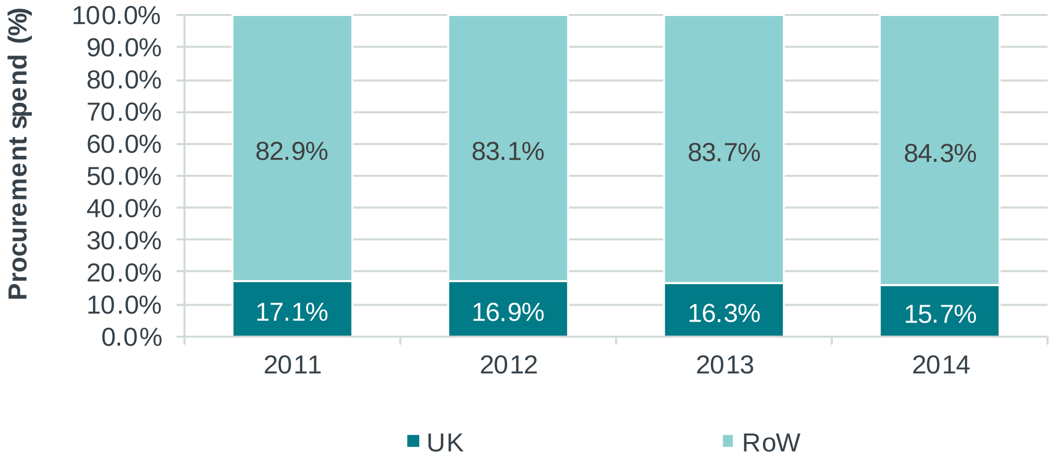
184 http://www.investinspain.org/invest/wcm/idc/groups/public/documents/documento/mde1/mzy3/~edisp/doc2015367125.pdf

Programme	Country	Brief Summary
CORAC – Civil Aviation Research Council	France	This group aims to coordinate French aerospace research for greater efficiency by bringing together industry stakeholders to work together: aircraft manufacturers, engine manufacturers, systems and equipment suppliers, government departments, etc.[185] Since the creation of CORAC, the volume of industry research has increased by 80% across the industry, with currently more than €900 million in activity per year, two-thirds of which is self-financed. Additionally, the research activity of mid-cap companies has multiplied by 2.5. More than 300 ETIs, SMEs and laboratories are now involved in CORAC's research programmes – not just the primes.[186]

Source: Various sources (as in footnotes)

In addition, as we show in the chart below, the UK's share of prime and Tier 1 spend[187] has declined in recent years (Figure 77). This provides some tentative support for the conclusion that the IUK aid is not out of line with international comparators.

Figure 77 Procurement spend by prime contractors and major Tier 1s within the UK vs. the rest of the world (RoW)



Source: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/536903/bis-16-310-aerospace-supply-chain-study.pdf

185 https://www.safran-group.com/media/corac-working-together-prepare-future-aerospace-industry-20180618

186 https://aerorecherchecorac.com/le-corac-presente-sa-nouvelle-feuille-de-route-a-la-presse-mars-2019/

187 This can be thought of as the UK's share of the LCA supply chains.

10 INDIRECT IMPACTS ON COMPETITION: MANUFACTURE OF ELECTRICAL COMPONENTS

This chapter assesses how Innovate UK (IUK) aid has impacted the manufacture of electrical components sector.

We assess whether IUK aid has had any negative indirect effects on this sector by testing the hypotheses we developed in Section 7.5. We test hypotheses using a mixed-methods approach and utilise an array of evidence, including analysis of the IUK monitoring data and secondary datasets, stakeholder interviews and market reports.

10.1 Hypotheses testing

10.1.1 Hypothesis #1: The aid awarded by IUK allows firms to undertake additional R&D which in certain cases leads to the development of new electrical components, which in turn causes harm to incumbent firms or distorts their incentives

CONCLUSION

The aid awarded by IUK to firms operating in this sector is often far from the market and will not translate into certain commercial success. This reduces the likelihood of a negative distortion to an incumbent firm's incentives. The rapidly evolving technologies which characterise this sector mean that the chances of an incumbent being in place is low.

The electronic component aid generally supports R&D that is not close to the market

We were told by stakeholders that research in this sector is most heavily concentrated in universities. Stakeholders suggested that IUK aid in this sector tends to focus on projects that build on fundamental research carried out in universities and may have Technology Readiness Levels (TRLs) of 4-5. Importantly the reliance on academic research in this sector suggests that both funded and non-funded firms are somewhat locked in to a particular R&D trajectory based on existing fundamental research. The European Commission's Framework for State Aid for Research and Development and Innovation (EC, 2014 C)[188] notes that significant exit barriers to innovation mean that competitors are more likely to maintain or increase their investment plans when aid is awarded. This in turn reduces the likelihood of crowding out. [189]

[188] See p 24, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XC0627(01)&from=EN

[189] It is important to note that while exit barriers may lower the forward-looking costs of innovation but does not mean that the companies will not drop innovative projects if not profitable on their own.

Our review of IUK monitoring data revealed that these projects often involved collaboration between private business and research institutions. This sort of cooperation between private and public is included in the EC's Common Methodology for State Aid Evaluation as a potential positive indirect effect of an aid scheme (EC, 2014 A).[190]

Individual projects funded by IUK in this sector vary in terms of their distance to market. As we described in Section 7.5, electrical components provide controlled electrical energy and delivery, and are put to a variety of uses in final products including consumer electronics, automotive electronics and data processing. Some of these sub-sectors will be characterised by greater levels of regulation and the associated development times will be longer.

Our qualitative engagement reveals that, in general, early-stage R&D investment in this sector can take a long time before translating into a commercial product. Certain R&D activity within specific electrical components sub-sectors will have significantly shorter timelines. However, we were told that it is unlikely that the IUK-funded projects will have an immediate commercial application.

For example, one of the firms we interviewed who had successfully applied for IUK funding started a project in 2014 to explore the incorporation of a new material into their device. The project lasted two years, and a further three years after the completion of the project they started to sell units which featured the new material. Therefore, in this specific case there was a five-year gap between project commencement and commercialisation, which they felt was broadly typical for their specific activity.

It is theoretically possible that the IUK aid could affect the behaviour of an unfunded incumbent firm who is already manufacturing a similar product that could over time be replaced. However, in this case the distance of the IUK electronic components aid from the market reduces the likelihood of any negative incentive effects on others active in the market. EC (2014 C) guidelines state that: 'the Commission will consider closeness to the market/category of the aid: the more the aid measure is aimed at activities close to the market, the more it is liable to develop significant crowding out effects'.[191]

In the current context, the distance from market of the aid means that incumbent firms could respond to R&D activity carried out by others by engaging in pro-competitive behaviour such as stepping up their own innovation efforts.

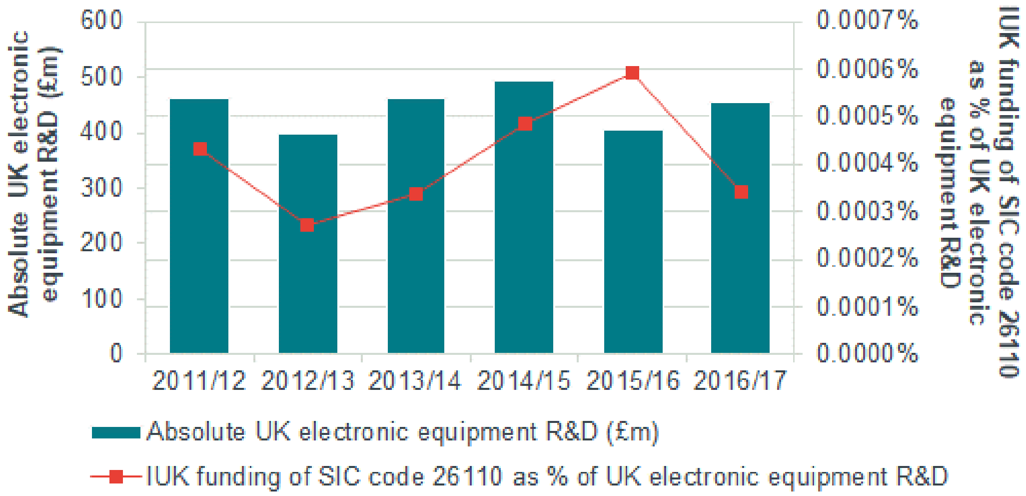
It is also important to note that R&D funding could come from a variety of other sources. In-scope IUK support for the sector is a very small share of overall investment. Our analysis of UK Business Enterprise Research and Development Business Structure Database (BSD) data shows that IUK funding is less than 0.5% of total sector R&D in all years (Figure 78).

As we presented in Section 6.4, there are other electronic SIC codes which also contain firms that received IUK funding during the period in question. Therefore, the actual proportion of all electronic R&D funded by IUK may in reality be slightly higher. This does not change the overall conclusion that the majority of R&D in the sector will not be funded by IUK.

[190] See p 36, https://ec.europa.eu/competition/state_aid/modernisation/state_aid_evaluation_methodology_en.pdf

[191] See p 24, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XC0627(01)&from=EN

Figure 78 IUK funding as a % of UK electrical components R&D



Source: Frontier analysis of UK Business Enterprise Research and Development data

The funded projects are risky with no certain benefit

Even for successful projects, there is likely to be a significant lag between IUK intervention and commercial outcomes in the electrical component market. However, during interviews, stakeholders emphasised the risks associated with undertaking research in this area. This means that a specific project may never lead to commercial outcomes.

For example, one firm we interviewed from this sector used IUK aid to develop an innovative type of electronic powerpack for use in hybrid vehicles that were being developed by another firm. The outputs from this project were ultimately never used. The beneficiary firm's collaborator decided not to pursue hybrid technology and shifted to fully electric vehicles. This meant that the funded firm's component was not required.

This single example is consistent with a wider body of evidence. Electrical components are generally not final products themselves but are incorporated into products developed by others. Therefore, a shift in strategy by an important customer could undermine the planned commercialisation strategy for a specific R&D project. When IUK established the Compound Semiconductor Catapult, more than 150 businesses active in this specific sector were consulted. The fragmented supply chain was raised as a particular challenge. Some companies may be reluctant to scale up without a proven market already in place.[192]

In the specific example we describe above, the funded firm was aware of the risks involved before undertaking the R&D and felt that this particular application had been neglected by competitors due to the associated uncertainties. Also, it is important to note that while there were no direct commercial benefits accruing to the funded firm in this instance (and therefore no significant harm caused to any incumbent firm), we were told that the knowledge developed as a result of carrying out this piece of work has been usefully applied in subsequent projects.

[192] https://csa.catapult.org.uk/wp-content/uploads/2018/07/Launching-the-Compound-Semiconductor-Applications-Catapult.pdf

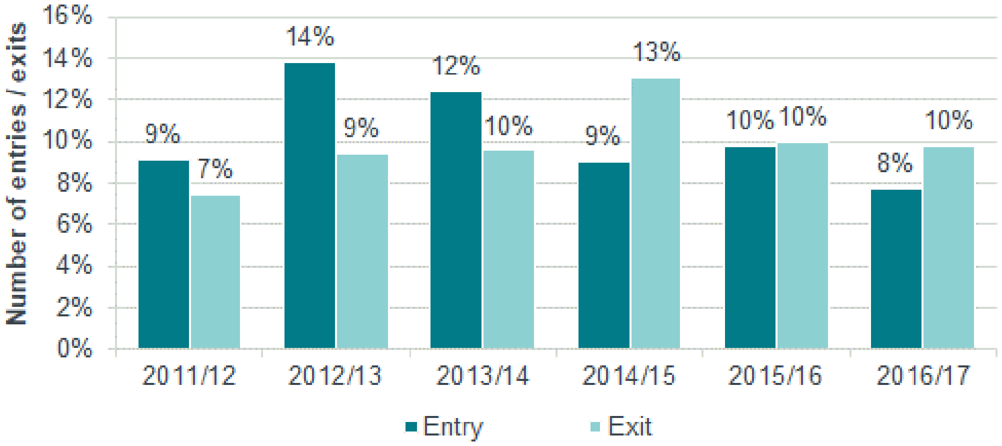
These types of risks reduce the chances of any distortions to competition or trade. If incumbent firms knew that an IUK-supported firm was virtually guaranteed commercial success, the potential negative impact on their incentives would be far larger and actual damage to the incumbent would be more likely. However, this appears unlikely to be the case.

Rapidly evolving technologies reduce the likelihood of an incumbent being damaged

The electronic components market is continuing to evolve. This evolution is in part due to the rapid rate of technological change in the sector which in some cases is necessitating significant capital investment (House of Commons Committee on Exiting the European Union, 2017 C).

Our quantitative analysis shows that the SIC code as a whole is characterised by significant rates of entry and exit (Figure 79), which will in part reflect the fast rate of technological evolution.

Figure 79 Entry and exit in the electrical components SIC code

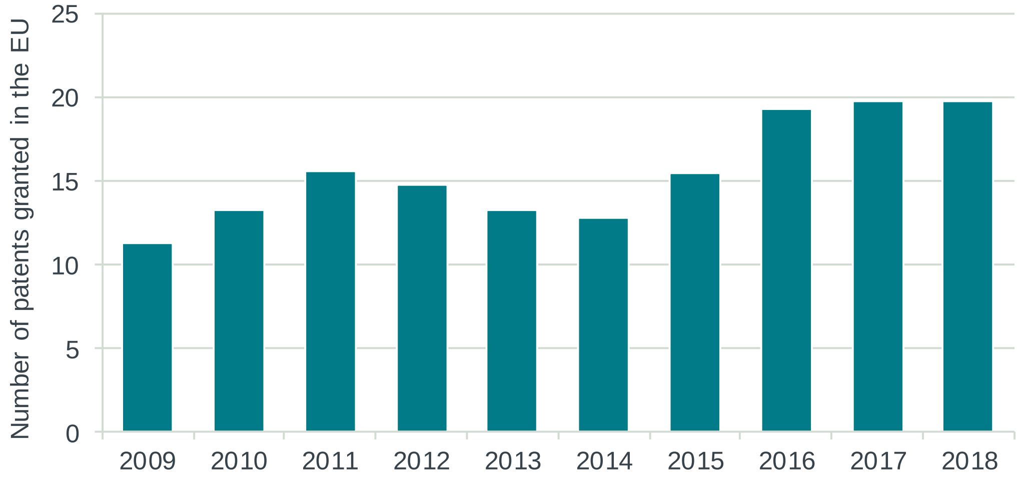


Source: Frontier analysis of the BSD

We also analysed the number of semiconductor patents awarded across the EU over the last decade (Figure 80). We can see some evidence of a rise in the number granted over time.[193]

[193] This refers to semiconductor patents only. There will be other patents awarded which are relevant to other type of electric component.

Figure 80 Number of semiconductor patents granted across the EU



Source: Frontier analysis of EPO annual reports

We were told by multiple stakeholders active in this sector that the research they were undertaking (with the support of IUK) was focused on the development of entirely new products or exploring new applications for existing technology. Therefore, there were no incumbent firms and this specific competition distortion could not arise. However, as we describe below, if a firm supported by IUK develops a new product where there is no existing incumbent, the size and diversity of the final product markets imply that they are unlikely to serve all of the demand for a long period of time. Specifically, other firms will seek to compete by developing their own components. For example, one firm who unsuccessfully applied for funding was interested in exploring the incorporation of power modules into a specific type of vehicle where no other company was operating.

This is consistent with the EC's Framework for State Aid for Research and Development and Innovation (EC, 2014 C),[194] which clarifies that the likelihood of distorted incentives is diminished where product innovation is about developing differentiated products.

Finally, the IUK-supported projects will only reach market and lead to the partial or full displacement of an incumbent firm when the electrical component in question represents a significant improvement on existing products. These will in some cases lead to improved outcomes on the demand side of the market in the form of higher quality or lower cost final products such as e-vehicles or consumer electronics.

10.1.2 Hypothesis #2: The aid allows successful firms to undertake additional R&D, which gives them an edge

[194] See p 24, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XC0627(01)&from=EN

relative to other firms in the race to develop an electrical component

The frequency and magnitude of distortions depend on market characteristics. The nature of competition in the electronic components sector suggests that significant concerns are unlikely

CONCLUSION

IUK aid may in some highly specific circumstances confer an advantage on recipient firms, which distorts competition, but the evidence suggests that these cases are likely to be extremely rare, as the final markets which use electronic components may be characterised by multiple players and the demand for electrical components will continue to grow.

It is important to consider the effects of the IUK aid on non-supported firms who are also carrying out similar R&D in the electrical components sector or considering carrying out related R&D in the future.

We know from the existing evaluation evidence reported in Chapter 5 that the IUK aid is having a material impact on beneficiaries' attitudes and behaviours. It is theoretically possible that these effects constitute an unfair advantage which could lead to distortions in some specific cases. In particular, the aid could have negative indirect effects if it:

- Discourages other firms from entering the R&D race, therefore crowding out research that would have been beneficial to society; and/or
- Allows the supported firm to reach market artificially ahead of the other firm(s). If these other firms were better placed prior to IUK's intervention they may have developed a superior product had IUK not intervened. This could lead to material losses for consumers if the supported firm (who developed an inferior product) is able to artificially maintain its place for a sustained period of time.

The likelihood of these distortions occurring in practice depends on the underlying market dynamics and structure. Specifically, it is more likely that the IUK support will encourage a firm to drop out of the R&D race in the electrical components sector or artificially maintain a strong position in supply chains where:

- The markets are static or shrinking. Therefore, the presence of one supported firm is more likely to disincentivise potential competitors from carrying out their own research as multiple firms may not be easily accommodated;
- The market contains sub-sectors which will be characterised by a single electrical components manufacturer serving all demand. Therefore, the first firm who reaches market in a specific sub-sector may be able to maintain a dominant position. The EC's Framework for State Aid for Research and Development and Innovation (EC, 2014 C)[195] notes that aid could result in non-funded firms halting their efforts to compete for a future 'winner-takes-all' market;

[195] See p 24, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XC0627(01)&from=EN

- The IUK funding accounts for a large share of R&D funding, therefore it is difficult for firms to carry out research without IUK support; or
- The IUK scheme is concentrated amongst a very small number of pre-determined recipients and other firms cannot apply.

As we summarise in Figure 81 below, in general, our engagement with stakeholders, desk research and quantitative analysis all strongly suggest that these conditions are unlikely to materialise consistently in this sector. We also provide further detail on each of these areas below.

Figure 81 Electronic components market characteristics

Market/aid characteristic	Competition implication
The market for electrical components will continue to grow as demand for final products is predicted to increase rapidly.	Reduces concerns
The final market for specific products (e.g. electronic vehicles) will be characterised by multiple players serving customers. Those final products will differ according to design/preferences etc. and it is likely that the underlying electrical components will also differ.	Reduces concerns
The IUK aid to the electrical components sector constitutes only a fraction of all R&D funding.	Reduces concerns
The IUK scheme does not pre-determine who should receive aid.	Reduces concerns

Source: Frontier

Demand for specific electrical components is expected to grow quickly and is unlikely to be served by a single firm

Demand for electrical components is growing rapidly in line with evolving technology, shifting consumer preferences and regulatory changes. Therefore, the number of connected devices and electronic vehicles is expected to rise rapidly. As we presented in Section 7.5, the market size of certain semiconductor applications, such as automotive and industrial, is projected to grow over 7% per annum in cumulative terms between 2017 and 2022.[196] Also, analysts estimate that the global market for compound semiconductors will grow from $66 billion today to $308 billion by 2030.[197]

The number of connected devices (all of which will rely on electrical components) is also expected to rise rapidly in the coming years. Specifically, Cisco expects that the global number of machine-to-machine connections will rise at a compound annual growth rate of 32% from 2017 to 2022.[198] Finally, JP Morgan[199] estimates that by 2025 electric vehicles and hybrid electric vehicles will account for 30% of all vehicles sales.

196 Based on or includes content supplied by IHS Markit, Technology Group, Worldwide Semiconductor Shipment Forecast March 2018

197 https://csa.catapult.org.uk/wp-content/uploads/2018/07/Launching-the-Compound-Semiconductor-Applications-Catapult.pdf

198 https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white-paper-c11-738429.html

199 https://www.jpmorgan.com/global/research/electric-vehicles

All of this evidence is in keeping with the impressions of UK stakeholders who we interviewed as part of this evaluation. In particular, we were told that emergent regulations, for example those incentivising take-up of e-vehicles, are leading to significant increases in demand.

However, this pattern of rapid growth does contrast slightly with the recent trends in turnover for the sector as a whole which we presented in Section 7.5. Our analysis shows that revenue growth across the entire SIC code in recent years has been slow. This is likely because the projected increase in demand referred to above will be concentrated in specific sub-sectors (which according to our qualitative engagement seems to be where IUK is most active) rather than covering all aspects of electrical components manufacturing. Some segments of the SIC code will be more established and therefore less dynamic.

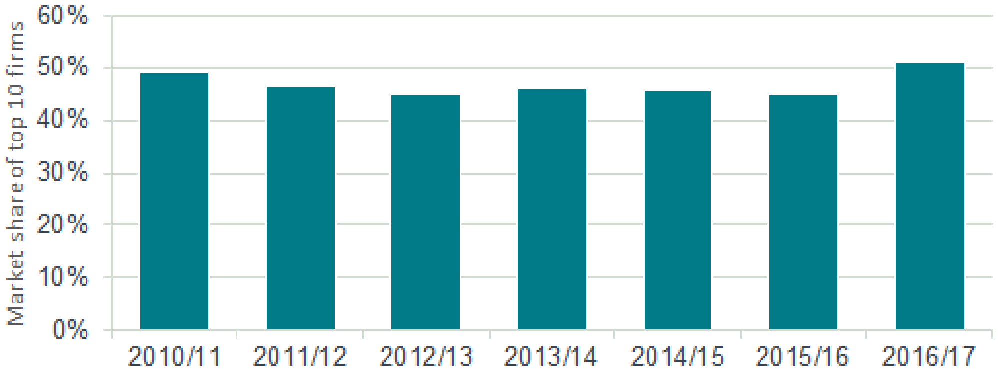
The final product markets which utilise electrical components are unlikely to be characterised by a 'winner-takes-all' structure, as different electronic components manufacturers will supply a range of different consumer-facing companies with slightly different products.

This view is supported by our qualitative engagement. One of the firms active in this sector who we interviewed noted that a small number of firms were already active in the specific niche they were in. Each product was slightly differentiated from the others. The electrical components were designed to suit a specific collaborator who would incorporate it into a final product for consumers. These collaborators were competing with each other to best serve customers. While the components all served a similar purpose, they did not have standard footprints and therefore could not be transferred into another collaborator's offering. Producers of final products which rely on electrical components will seek to avoid a situation where they have to rely on a single supplier.

Therefore, the presence of one firm carrying out R&D to develop a specific type of electrical component is unlikely to dissuade other firms from pursuing related research.

One quantitative piece of evidence which provides tentative support for this conclusion is the level of concentration across the entire SIC code. Our analysis shows that the combined market share of the ten largest firms is consistently around 50% (Figure 82). The entire SIC code will not perfectly match a specific economic market and will include multiple sub-sectors where concentration could be higher. However, it is reassuring that the overall concentration rates are not rising significantly.

Figure 82 Combined market share of top ten firms in the electrical components SIC code



Source: Frontier analysis of the BSD

This is in keeping with the conclusion of our qualitative analysis that the emergence of a single dominant electrical components manufacturer is unlikely.

IUK aid is not a major source of R&D funding in the sector and is based on an open application process

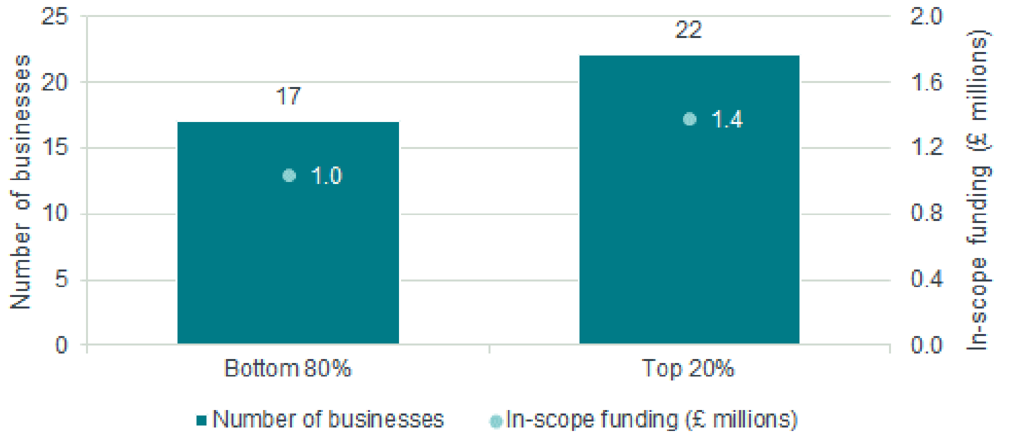
As we set out above, the IUK aid constitutes only a small proportion of all R&D carried out across the electrical components sector. Specifically, 0.4% of the £0.41 billion total R&D expenditure in the manufacture of electrical components SIC code in the 2015/16 financial year was funded by IUK. This clearly implies that IUK aid will not be the only factor in determining whether electrical components under development reach market. There are other funding options open to firms in this sector. Even where IUK does provide support for a specific project, the recipient firms carrying out the R&D will have to provide match funding.

The IUK scheme awards funding on the basis of a transparent and open application process, which is open to any UK firm. This significantly reduces the possibility of one firm being repeatedly and materially disadvantaged. Importantly, firms who were unsuccessful can apply again following feedback. Our qualitative engagement suggests that this occurs frequently. The EC's (2014 C)[200] Framework for State Aid for Research and Development and Innovation states that aid which is awarded on the basis of an open selection process, which draws on transparent, objective and non-discriminatory criteria, will be viewed more positively.

Our analysis of IUK monitoring data linked to the BSD records shows that IUK funds a variety of firms each year who are active in this sector. Specifically, 32 electrical component businesses received IUK aid in 2015/16. On average, IUK tends to fund larger firms within the electrical components SIC code. However, we find that funding is not exclusively restricted to the largest firms. Our analysis of BSD data shows that IUK provided £1.6 million of funding to firms active in this sector in 2015/16. £0.6 million of this went to firms who were not in the largest 20% of firms as measured by turnover (Figure 83).

[200] See p 24, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XC0627(01)&from=EN

Figure 83 IUK funding of firms in the electrical components SIC code by size, 2015/16



Source: Frontier analysis of the BSD

In the EC's Common Methodology for State Evaluation (EC, 2014 A)[201] the proportion of old versus young firms is included as a possible result indicator for negative indirect impacts of the aid scheme. Our analysis of the BSD suggests that the IUK aid is slightly more likely to be awarded to older firms in this sector. Specifically, we find that average funded firms are slightly older (18.5 years) than unfunded firms (14 years). This could be driven by a number of factors such as differences in the propensity to carry out R&D, and does not reflect a systematic bias in the award process.

10.1.3 Hypothesis #3: The aid encourages recipients to locate in or carry out R&D in the UK

CONCLUSION

The IUK aid scheme is non-discriminatory as any UK-based firm can apply. Electrical component firms' location decisions are influenced by several factors, such as closeness to customers. The magnitude of funding provided by IUK will not be of a sufficient magnitude to materially influence this.

Location decisions for firms undertaking electrical component R&D will be driven by several factors

Our qualitative analysis revealed that there are several important drivers of location decisions for firms active in this sector.

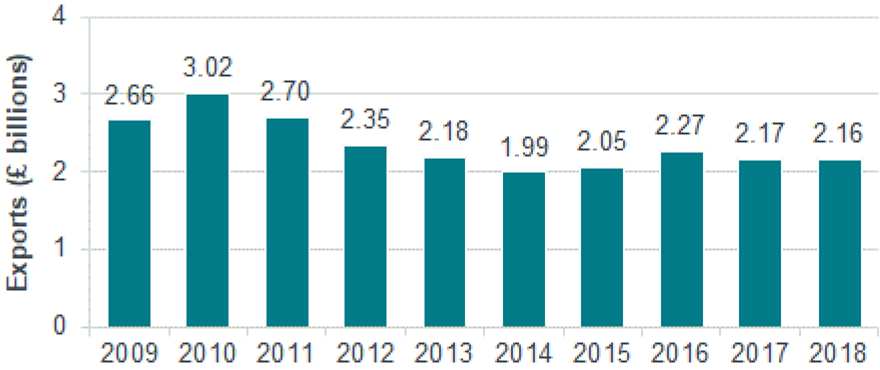
One firm who successfully applied for IUK funding noted that wherever possible they sought to locate their operations close to their customers who would be incorporating the components into their products. Basing R&D and manufacturing activities in close proximity to their customers' sites allowed firms to better

[201] See p 36, https://ec.europa.eu/competition/state_aid/modernisation/state_aid_evaluation_methodology_en.pdf

understand their collaborators' needs and helped to foster longer lasting commercial linkages.

As we note above in Section 7.5, the supply chain for firms active in this sector is typically global. We know from our analysis of ONS trade data that exports are a very important source of income for UK-based firms active in this sector (Figure 84).

Figure 84 UK export value of electronic components and boards (£ billion)



Source: UK Trade in goods by Classification of Product by Activity

Note: The most comparable export code included both electronic components and boards.

This is in keeping with the reflections of market stakeholders who we interviewed. Firms active in this sector noted the importance of import duties and tariffs in determining the location decisions.

Finally, the availability of skilled employees with sufficient engineering expertise who can carry out this type of research will also be a crucial factor in determining the relative attractiveness of potential locations.

The availability of funding to carry out R&D is important but IUK aid is not sufficient to materially distort location decisions

Stakeholders who we engaged with did note the overall funding environment was a relevant factor in determining where to carry out R&D or where to locate a start-up.

The IUK aid plays an important role in driving ahead certain projects that would not otherwise take place. However, as we note above it constitutes only a small proportion of overall investment in R&D within the sector as a whole. Therefore, it seems very unlikely that it would be the deciding factor in a firm's location decisions when so many other factors are also highly relevant. This likelihood is reduced further because firms cannot be certain of receiving IUK aid even if they locate in the UK. Any project will only receive funding following a competitive application process, which may result in a rejection.

11 PROPORTIONALITY

11.1 Introduction

One of the four dimensions we considered when evaluating Innovate UK's (IUK) aid scheme is proportionality. This is in line with the European Commission's Common Methodology for State Aid Evaluation, which states that an evaluation could examine the proportionality of the chosen aid instrument (EC, 2014 A).[202] Aid is judged to be proportionate only if the same result could not be reached with less aid.

In this chapter we present our findings regarding proportionality. As we set out in Chapter 3, we analysed proportionality using a number of approaches. Firstly, we undertook a quantitative analysis of IUK monitoring data covering the entire scheme to determine the aid intensity of each in-scope project. Also, as per the evaluation plan, we collated available programme level evidence on differences in impact according to the size of grant awarded. Finally, we explored the process by which IUK makes its funding decisions to draw out evidence relevant to proportionality.

11.2 Aid intensities

11.2.1 EC maximum aid intensities

As we explained in Chapter 3, the EC has set out maximum aid intensities, which state the proportion of eligible project costs that can be met by aid. These intensities are set out to ensure that the level of aid is proportionate (EC, 2014 C).[203] Specifically, the permitted intensity of the aid will be higher when the relevant project is far away from the market and when the recipient organisation is smaller, as these scenarios will be characterised by more acute market failures and the risk of competition distortions is smaller. We set out the relevant aid intensities for each category of aid in Figure 85.

Figure 85 Maximum aid intensities for R&D projects

Aid category	Type of aid	Small enterprise	Medium-sized enterprise	Large enterprise
Aid for R&D projects	Fundamental research	100%	100%	100%
Aid for R&D projects	Industrial research[204]	70%	60%	50%

[202] See p 4, https://ec.europa.eu/competition/state_aid/modernisation/state_aid_evaluation_methodology_en.pdf

[203] See p 29, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XC0627(01)&from=EN

[204] Maximum thresholds rise if the project involves effective collaboration or the results of the project are widely disseminated.

Aid category	Type of aid	Small enterprise	Medium-sized enterprise	Large enterprise
Aid for R&D projects	Experimental development[205]	45%	35%	25%
Aid for R&D projects	Aid for feasibility studies	70%	60%	50%
Aid for R&D projects	Aid for the construction and upgrade of research infrastructures	50%	50%	50%
Aid for R&D projects	Innovation aid for SMEs	50%	50%	-
Aid for R&D projects	Aid for process and organisational innovation	50%	50%	15%
Aid for innovation clusters	Investment aid[206]	50%	50%	50%
Aid for innovation clusters	Operating aid	50%	50%	50%

Source: EC (2014 B)

11.2.2 Intensity of IUK aid scheme

Importantly, as we show below, each element of IUK's scheme operates within the defined maximum aid intensities, meaning they can generally be deemed to be proportionate. Each project which is supported by IUK must feature match funding. This is made clear to all applicants and any project application which requests funding of more than the maximum thresholds is rejected.

Aid intensity by recipient type

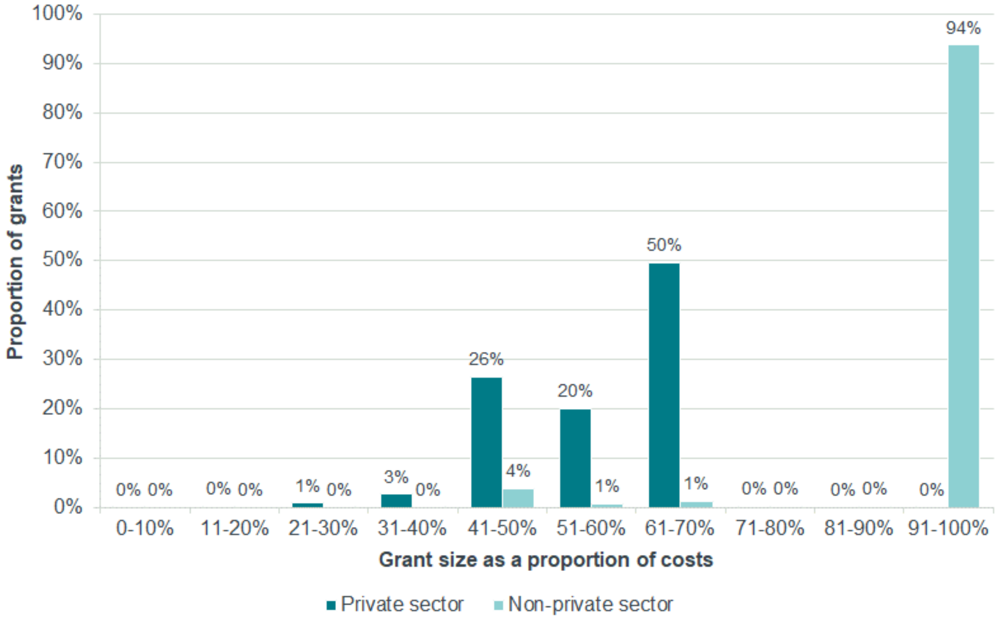
As part of our analysis we calculated aid intensity, measured by the proportion of recipient firm costs covered by the grant, for private sector and non-private sector organisations. We focused on projects that started after January 2015 and were part of competitions that opened after 2015 as this captures the aid subject to the maximum aid intensities set out in Figure 85.[207] Amongst private sector firms, most grants cover around half of a recipient firm's costs, specifically, 96% of grants cover between 41% and 70% of a firm's costs. These projects are still in line with the EC guidelines referred to above.

[205] Maximum thresholds rise if the project involves effective collaboration or the results of the project are widely disseminated.

[206] Thresholds rise if the investment aid is in assisted regions fulfilling the conditions of Article 107(3)(c) or Article 107(3)(a) of the Treaty.

[207] Projects funded by competitions that opened before 2015 are subject to slightly different maximum aid intensities.

Figure 86 In-scope aid intensity (2014/15 to 2017/18)



Source: *Frontier analysis of Innovate UK data*

Note: *(1) Excludes a small number of grants with high aid intensities where self-reported private sector variable is inaccurate. Also excludes ICURe funding which has 100% aid intensity since due to an agreement regarding set-up costs. (2) Sample includes organisations that received in-scope IUK funding between 2014/15 and 2017/18, where projects started after January 2015 and where competitions opened after January 2015. (3) Based on funding committed by Innovate UK. (4) A single recipient organisation can receive multiple grants if it received funding for multiple different projects.*

In contrast, aid intensity for non-private sector organisations is much higher, usually close to 100%. In many cases the non-private sector recipients of IUK aid are not the final beneficiaries. Rather IUK will fund organisations such as the Centre for Process Innovation[208], Crop Health and Protection[209] and the Fraunhofer UK Research Limited[210] who are themselves non-profit Research and Technology Organisations (RTOs)[211] and act as intermediaries by distributing that funding further, often within a specific sector. Therefore, the intensity of the IUK award in those cases is not relevant. The final funding awards granted by the intermediaries will themselves adheres to the EC's aid intensities.

In other cases, the non-private sector recipients will be universities where the aid intensity guidelines set out above do not apply.

Aid intensity by programme

Figure 87 shows there is variation in aid intensity across programmes for private sector organisations. The Catalyst programme has the projects with the highest

208 https://www.uk-cpi.com/

209 https://chap-solutions.co.uk/

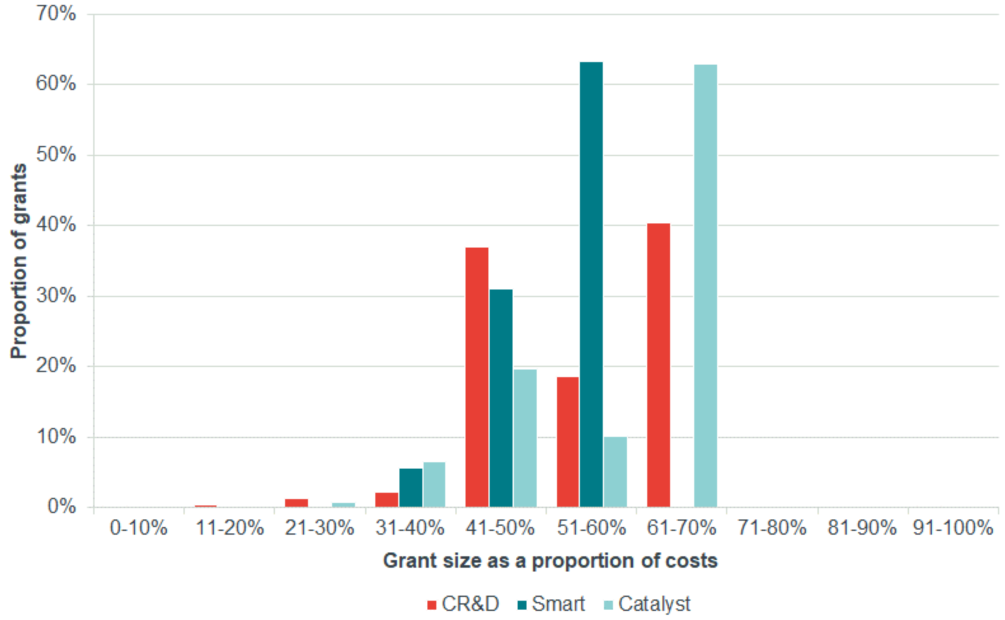
210 https://www.fraunhofer.co.uk/en/FraunhoferUKResearchHome.html

211 https://s3platform.jrc.ec.europa.eu/rtos The European Association for RTOs (EARTO) defines RTOs as "regional and national actors whose core mission is to harness science and technology in the service of innovation or public bodies and industry, to improve the quality of life and build economic competitiveness in Europe. RTOs are generally non-profit organisations and their revenues are re-employed to fund new innovation cycles."

aid intensities with around 63% of projects undertaken by private sector firms receiving aid covering 61-70% of costs. This is in line with expectations as the Catalyst programmes explicitly requires the involvement of SME's. For example to apply for the 2019 wave of Biomedical Catalyst funding the lead applicant had to be a UK based micro, small or medium sized enterprise.[212] For both CR&D awards and awards made under the Smart programme average intensity is significantly lower. The most common intensity CR&D awards is the 61-70% range while the most common intensity for Smart awards is 51-60%.

Data is not yet available for the aid intensity of newer programmes such as the Innovation Loans pilot and the Investment Accelerator pilot. It will be important for IUK to track aid intensity for these support mechanism in the future.

Figure 87 Aid intensity for private sector organisations for in-scope programmes between 2014/15 and 2017/18



Source: Frontier analysis of Innovate UK data

Note: (1) Excludes a small number of grants with high aid intensities where self-reported private sector variable is inaccurate. ICURe funding has 100% aid intensity but is not shown as this is due to an agreement regarding set-up costs. (2) Sample includes organisations that received in-scope IUK funding between 2014/15 and 2017/18, where projects started after January 2015 and where competitions opened after January 2015. (3) Based on funding committed by Innovate UK. (4) A single recipient organisation can receive multiple grants if it received funding for multiple different projects.

11.2.3 Difference in impact by size of grant

There is relatively little evidence to date regarding differences in impact by size of grant awarded. However, the PACEC (2011) evaluation of the CR&D programme does report differential gross value added (GVA)[213] estimates for small, medium and large grants.

[212] https://apply-for-innovation-funding.service.gov.uk/competition/306/overview#eligibility

[213] GVA in this instance is calculated based on the number of additional jobs the programme resulted in.

The authors found that the total per pound impact was positive for grants of all sizes but greater for smaller grants relative to larger grants. This information is presented below in Figure 88.

Figure 88 Gross value added per pound for CR&D projects of different size

Source: PACEC (2011)

As per the evaluation plan, this is important evidence and IUK should consider including analyses of this type in future evaluations. However, it does not necessarily imply that larger grants were not proportional. The information presented above does not capture the marginal impact of funding above the small or medium grant size thresholds defined by the authors. In addition, the larger projects may be inherently different in nature to the small and medium-sized projects. For example, it could be that the larger grants tend to fund projects where GVA effects are slower to develop. It is also not clear how many surveyed projects fall into each category, and therefore some of the apparent difference may be driven by random variation as a result of relatively small sample sizes.

11.2.4 Wider proportionality evidence from IUK governance processes

IUK decisions suggest that project costs are scrutinised

Each application for funding which is submitted to IUK is subjected to an independent assessment process. The precise mechanism varies across different programmes within the scheme but typically involves a thorough review of each application by qualified experts in terms of its quality and cost.

Existing process evaluations of individual programmes provide us with some indication that proportionality is a key consideration. Firstly, the process evaluation of the Catalyst programmes (SQW, 2017 A, 2017 B) showed that on average larger applications are less likely to be funded by IUK (Figure 89). Specifically, 60% of applicants seeking less than £25k successfully applied for funding, whereas the equivalent proportion for those applying for more than £1 million was only 31%. This is consistent with a view that larger applications were less likely to be proportionate.

Figure 89 Proportion of successful Catalyst applications by scale of grant requested

Source: SQW (2017 B)

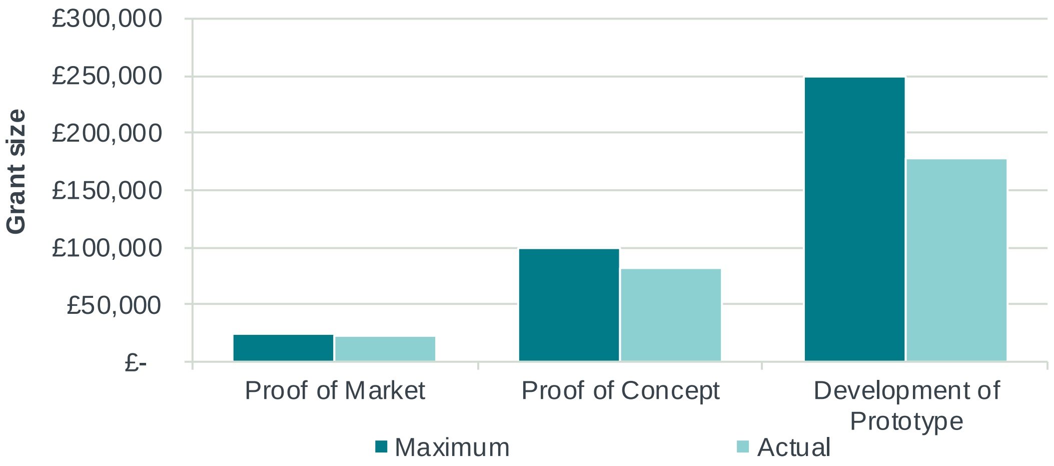
In addition, a process evaluation of the joint IUK/BEIS/ATI sub-programme, noted that all applications were now subject to a value-for-money (VfM) assessment. The evaluators judged that the VfM framework used was largely fit for purpose (Ipsos MORI, 2017 C).

IUK regularly funds projects below their own absolute funding caps

Data collected as part of the retrospective impact and process evaluation of the Smart programme (SQW, 2015) showed that projects are routinely funded at below the absolute maximum grant levels set by IUK. Applicants can apply for three different types of grant within the Smart programme: Proof of Market grants, Proof of Concept grants and Development of Prototype grants. As we illustrate below in Figure 90, the average grant size awarded is below the maximum cap set by IUK in each case.

Specifically, over the period covered by the impact evaluation, the average Proof of Market grant was £22,000 relative to a maximum of £25,000, the average Proof of Concept grant was £82,000 relative to a maximum of £100,000, and the average Development of Prototype grant was £178,000 relative to a maximum of £250,000. This suggests that each application is proportionally funded based on actual need rather than administrative thresholds.

Figure 90 Maximum and actual funding levels by grant type in the Smart programme



Source: SQW (2015)

Adjustments to costs

The process and baseline impact evaluation of the Biomedical Catalyst revealed that feedback from IUK resulted in adjustments to project costs (Ipsos MORI, 2016 B). The projects that received this feedback were not necessarily over the thresholds to begin with. However, this does show that IUK is giving careful consideration to the amount of funding awarded to each project and not accepting the suggestions made by applicants.

Grant funding can only be claimed in arrears

Recipients of grant funding can claim quarterly in arrears. Before any quarterly payment is made, participants must submit reports which can cover financial forecasts and project plans.[214] This process ensures transparency and allows IUK to monitor whether applicants are following a coherent plan and spending precisely the amount of public funds offered on eligible costs.

214 https://www.gov.uk/guidance/innovate-uk-funding-general-guidance-for-applicants

12 APPROPRIATENESS

One of the four dimensions we are considering when evaluating Innovate UK's (IUK) aid scheme is appropriateness. State aid needs to be appropriate to the task in hand. State aid is not the only policy instrument that Member States can use to promote innovation (EC, 2009 A).[215]

The most appropriate form of State aid will be the aid instruments which achieve the overall objectives causing the fewest distortions to competition and trade. To assess the appropriateness of the IUK scheme we:

- set out why public sector intervention of any kind is needed in the current context;
- describe why State aid is an appropriate policy approach to address the apparent market failure;
- consider how the specific aid instruments chosen as part of the current scheme are appropriate in addressing specific challenges faced by those at different stages within the innovation process; and
- explore how the IUK scheme fits into a wider programme of support.

12.1 The scheme is targeted at addressing known market failures

It is universally accepted that R&D activity is characterised by market failures, which will lead to an underinvestment in innovation and a loss of welfare, without some public sector innovation. The European Commission (EC, 2014 B)[216] highlights externalities as a cause of this market failure, as actors other than the innovator can benefit from R&D activity. In addition, R&D projects might suffer from insufficient access to finance (due to asymmetric information) or from coordination problems amongst firms (EC, 2014 B).[217]

This issue is acknowledged by the UK government. BEIS's (2017) Industrial Strategy sets out a long-term plan to boost the productivity of the country. This strategy emphasises the importance of innovation in meeting societal objectives and highlights the relative underinvestment in R&D for the UK. A recent survey of the UK economy by the OECD (2017) highlighted that the spending on R&D is below average. The UK government's goal is to increase R&D to 2.4% of GDP within a decade (BEIS, 2017).

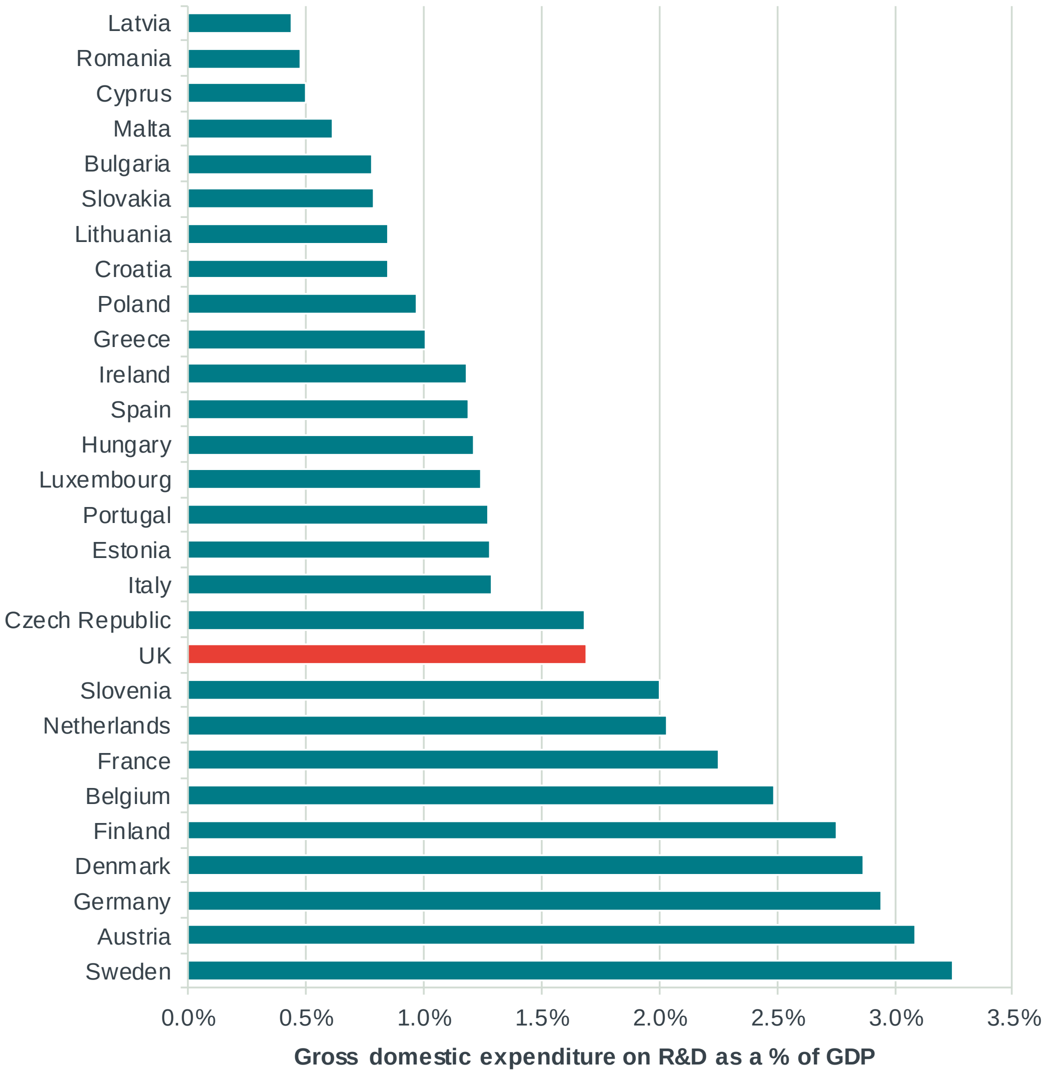
In Figure 91 below we illustrate how the UK compares to other EU countries in terms of relative investment in R&D.

[215] See p 11, https://ec.europa.eu/competition/state_aid/reform/economic_assessment_en.pdf

[216] See for example p 9 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0651&from=EN

[217] See for example p 8 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0651&from=EN

Figure 91 Relative investment in R&D by EU countries



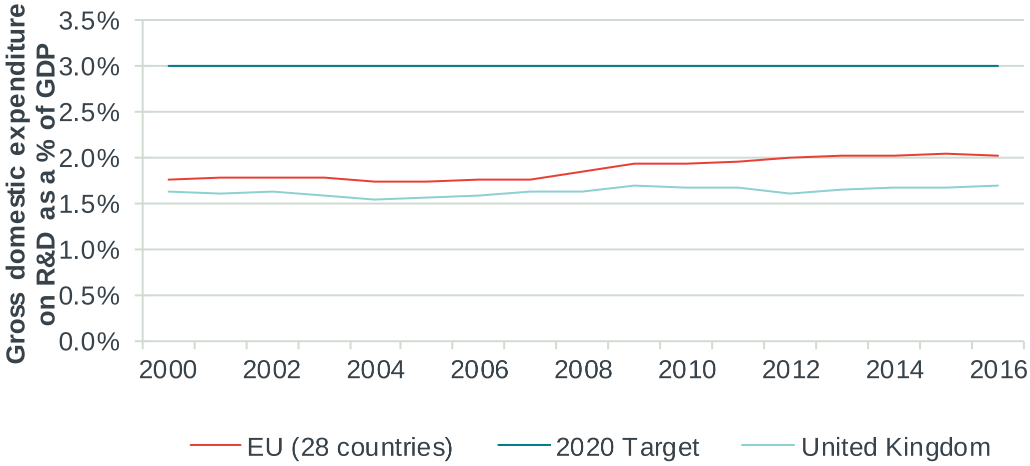
Source: Eurostat (2018)[218]

The EU has an explicit target for expenditure on R&D as a % of GDP to reach 3% by 2020.[219] In Figure 92 we show that R&D intensity in the EU has plateaued in recent years after a period of slow growth. Current intensity of 2.03% is still some distance away from the 3% target. This is also the case if we look at the UK individually rather than the EU as a whole.

[218] https://ec.europa.eu/eurostat/tgm/table.do?tab=table&plugin=1&language=en&pcode=t2020_20

[219] https://ec.europa.eu/eurostat/tgm/table.do?tab=table&plugin=1&language=en&pcode=t2020_20

Figure 92 R&D intensity in the EU and the UK (2000-2016)



Source: Eurostat (2018)[220]

12.2 State aid helps to mitigate underinvestment by addressing specific market failures

The existing programme-specific evaluations contain a rich source of information regarding the underlying rationales behind each intervention. Each programme is designed to address specific market failures which limit R&D activity:

- State aid funding delivered through the Biomedical Catalyst helps to overcome free-riding issues which often characterise the life sciences sector, as the results of clinical trials are often made publicly available (Ipsos MORI, 2016 B).
- State aid grants delivered via the Agri-tech Catalyst help to stimulate R&D capacity as farms are often relatively small businesses with limited financial capacity to invest in R&D (SQW, 2017 B, 2017 C).
- The Smart programme helps to tackle issues of risk and uncertainty around the benefits of R&D that prevent optimal levels of investment (SQW, 2015).

The EU's General Block Exemption Regulation[221] acknowledges that State aid is an appropriate policy tool to deal with these market failures and allows Member States to provide State aid for R&D projects with prior notification (EC, 2014 C).

12.3 There are a wide variety of support options within the aid scheme which are appropriately targeted at addressing specific challenges

Member States can make different choices regarding the specific State aid instruments they choose (EC, 2009). IUK acknowledges that actors at different stages of innovation need different types of funding support. Entrepreneurs,

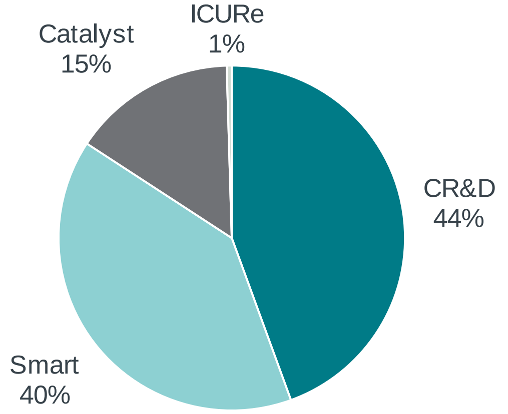
[220] https://ec.europa.eu/eurostat/tgm/table.do?tab=table&plugin=1&language=en&pcode=t2020_20

[221] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XC0627(01)&from=EN

businesses and academics will encounter different challenges depending on where they are on the journey from initial idea to market success.

It is therefore crucial that the IUK scheme provides differential support which is specifically targeted at addressing the challenge at hand. The IUK scheme is composed of a number of programmes. As we set out in Chapter 3, IUK funds projects via these individual programmes. During the period 2014/15 to 2017/18, our analysis shows that the largest single programme only accounted for 44% of the total number of projects (Figure 93). In the future this is likely to fall further as emergent pilot programmes such as the Innovation Loans Pilot start to scale up.

Figure 93 Share of projects by programmes, (2014/15 to 2017/18)



Source: Frontier analysis of IUK data

Note: (1) Sample includes organisations that received in-scope IUK funding between 2014/15 and 2017/18. (2) A single recipient organisation can receive multiple grants if it received funding for multiple different projects. (3) Includes both private and non-private sector firms.

The programmes with the IUK scheme serve different purposes

Each of the IUK programmes addresses a different need and they are appropriate in different situations. IUK's scheme is therefore tailored to provide appropriate support at every part of this journey.

For example, Smart grants assist small and medium enterprises including pre-start-ups, who are at the early stages of the commercialisation process (SQW, 2015). This support is further sub-divided into three types of grants, each of which is appropriate in certain situations within the early-stage support process:

- **Proof of market**: An assessment of commercial viability of the new product, process or service to be later developed;
- **Proof of concept**: Feasibility studies, prototyping, testing and/or demonstration to provide basic proof of feasibility; and
- **Development of prototype**: A pre-production prototype of a technologically innovative product, service or process.

Grants are the appropriate instrument in this case as the projects are far away from the market.

More recently, following engagement with businesses, IUK has introduced Innovation Loans (IUK, 2017 B). This type of support aims to encourage later-stage R&D with a clear route to commercial success. Therefore, beneficiaries should be able to repay the loan in the next five years.

Similarly, IUK has also introduced the Investment Accelerator Pilot (SQW, 2019 A). This offers a package of public sector grants coupled with private equity investment. This programme aims to support early-stage R&D and accelerate the route to commercialisation.

On the other hand, the ICURe programme has a completely different target audience. That programme is focused on academics and is designed to help overcome barriers to the commercialisation of scientific research.

These examples serve to illustrate the variation in support available within the IUK scheme and indicate how specific interventions are targeted appropriately at specific issues.

It is not yet possible to determine whether one type of support mechanism is more effective than others

As noted in the evaluation plan, it may be that one type of support mechanism (grants for example) within the portfolio consistently leads to larger direct impacts than other programmes (such as loans). If we found that one type of support mechanism consistently had no positive effects on recipients, we could then conclude that it was inappropriate in the current context.

However, currently it is not possible for us to make this comparison in a robust manner. As we set out in Section 4.1 the individual programmes which make up the scheme are at different stages of the evaluation cycle. For example, currently the only evaluation evidence we have which relates to loans comes from the pilot evaluation of the Innovation Loans programme. Further work which is already underway needs to be completed before we can draw final conclusions on the relative effectiveness, and therefore appropriateness, of different support mechanisms.

Importantly, as we noted in Section 4.1, each of the individual IUK programmes has generated some positive direct effects, which provides some assurance that they are being appropriately targeted.

We ruled out comparing the effectiveness of the IUK scheme relative to equivalent programmes which are implemented by other Member States across the EU as part of our assessment. This could in theory help to determine whether one scheme is more or less appropriate than another. However, this sort of comparison is unlikely to be conclusive as the relevant contexts which apply to each scheme will differ markedly and equivalent evidence will not always be available on a consistent basis.

12.3.1 The aid scheme is only one part of a wider support package offered to UK businesses to encourage innovation

The IUK aid scheme is an important part of the UK's efforts to stimulate R&D activity. However, State aid will not be the appropriate policy mechanism in all cases. As such, the aid scheme which is the focus of this evaluation sits within a wider support programme. The other policy interventions described below indicate that the aid scheme is only used where appropriate.

Other innovation support activity

IUK encourages R&D activity not only by offering grants and loans but also by encouraging collaboration and overcoming fragmented links between different groups in the innovation pathway. For example, IUK commissions the Knowledge Transfer Network (KTN) to bring together businesses, entrepreneurs, academics and funders to help them develop new products, processes and services (SQW, 2018 A). The KTN has been shown to be effective in increasing participants' levels of investment in R&D. Also, even the in-scope programmes which do offer aid in the form of grant or loan funding often contain other non-financial support mechanisms. For example, the ICUREe programme included a residential training programme and business mentorship as well as funding (Ipsos MORI, 2018).

In addition, HMRC offers businesses R&D tax relief. Companies that work on innovative projects in science and technology can claim Corporation Tax relief.[222] R&D tax credits have been available since 2000 and are a key government policy for raising levels of business investment in R&D (House of Commons Business and Enterprise Committee, 2009). Qualifying projects are required to focus on advancing science and technology and they must also try to overcome uncertainty. There are two categories of relief offered:

- SME R&D Relief which allows companies to either deduct qualifying R&D costs from their annual profit (on top of normal deductions) or claim tax credit if the company is loss making (HMRC, 2018 A).
- R&D Expenditure Credit which can be claimed by large companies for working on R&D projects. This replaces the relief previously available under the large company scheme (HMRC, 2018 A).

HMRC also oversees four[223] venture capital schemes which are designed to help small or medium-sized companies and social enterprises to grow by attracting investment. They offer tax relief to individuals who buy and hold new shares, bonds or assets in those SMEs (HMRC, 2018 B).[224] Companies that carry out R&D or innovation can get more funding through venture capital schemes than other types of companies (HMRC, 2018 C).[225]

BEIS's (2017) Industrial Strategy also highlights the importance of the education system in attracting R&D; for example, supporting universities and businesses to develop an industry-funded master's programme.

UKRI also supports researchers and develops capacity through a number of mechanisms, training skilled people and supporting their movement within the economy.

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222 https://www.gov.uk/guidance/corporation-tax-research-and-development-rd-relief

223 The Enterprise Investment Scheme, The Seed Enterprise Investment Scheme, Social Investment Tax Relief and Venture capital trust.

224 https://www.gov.uk/guidance/venture-capital-schemes-raise-money-by-offering-tax-reliefs-to-investors

225 https://www.gov.uk/guidance/use-the-enterprise-investment-scheme-eis-to-raise-money-for-research-development-or-innovation

These examples highlight that the UK is not solely relying on the IUK scheme to boost R&D.

13 REFERENCES

ATI (Aerospace Technology Institute), 2018 A. UK Aerospace Research and Technology (R&T) Programme. Guidance for Applicants. (https://www.ati.org.uk/wp-content/uploads/2017/02/UK-Aerospace-Research-and-Technology-RT-Programme-Guidance-for-Applicants-v2.23.pdf)

ATI (Aerospace Technology Institute), 2018 B. The Economics of Aerospace: The Evolving Aerospace R&D Landscape. (https://www.ati.org.uk/wp-content/uploads/2017/02/INSIGHT_10-The-Evolving-Aerospace-RD-Landscape.pdf)

BEIS (Department for Business, Energy and Industrial Strategy), 2017. Industrial Strategy: Building a Britain Fit for the Future. (https://www.gov.uk/government/publications/industrial-strategy-building-a-britain-fit-for-the-future)

Bell, T. and D. Tomlinson, 2018. Is Everybody Concentrating? Recent Trends in Product and Labour Market Concentration in the UK.

Belmin, P. and H. Zenger, 2016. Research, Development and Innovation Aid. In Werner, P. and V. Verouden (eds.) *EU State Aid Control. Law and Economics*.

BIS (Department for Business, Innovation and Skills), 2011. The State Aid Guide. Guidance for State Aid Practitioners (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/31700/11-1040-state-aid-guide.pdf)

Bureau van Dijk Electronic Publishing, 2019. Fame: The Definitive Source of Private Company Information in the UK and Ireland. (https://www.bvdinfo.com/en-gb/-/media/brochure-library/fame.pdf)

Companies House, 2018. Standard Industrial Classification of Economic Activities (SIC). (https://www.gov.uk/government/publications/standard-industrial-classification-of-economic-activities-sic)

Competition Policy International, 2019. The Airbus and Boeing Duopoly: Would More Aggressive Antitrust Enforcement Benefit the Commercial Aviation Industry?. (https://www.competitionpolicyinternational.com/the-airbus-and-boeing-duopoly-would-more-aggressive-antitrust-enforcement-benefit-the-commercial-aviation-industry/)

Copenhagen Economics, 2018. Study on the Economic Impact of Supplementary Protection Certificates, Pharmaceutical Incentives and Rewards in Europe. (https://ec.europa.eu/health/sites/health/files/human-use/docs/pharmaceuticals_incentives_study_en.pdf)

EC (European Commission), 1997. COMMISSION NOTICE on the Definition of Relevant Market for the Purposes of Community Competition Law (97/C 372 /03). (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31997Y1209(01)&from=EN)

EC (European Commission), 2009 A. Common Principles for an Economic Assessment of the Compatibility of State Aid under Article 87.3 EC-Treaty. (http://ec.europa.eu/competition/state_aid/reform/economic_assessment_en.pdf)

EC (European Commission), 2009 B. Pharmaceutical Sector Inquiry Final Report. (https://ec.europa.eu/competition/sectors/pharmaceuticals/inquiry/staff_working_paper_part1.pdf)

EC (European Commission), 2010 A. Communication from the Commission. Europe 2020 A Strategy for Smart, Sustainable and Inclusive Growth. (https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex:52010DC2020)

EC (European Commission), 2010 B. Orphan Medical Products. (https://ec.europa.eu/health/human-use/orphan-medicines_en)

EC (European Commission), 2013. Council Regulation (EU) No 733/2013 of 22 July 2013 amending Regulation (EC) No 994/98 on the application of Articles 92 and 93 of the Treaty establishing the European Community to certain categories of horizontal State aid Text with EEA relevance. *OJ L 204, 31.7.2013, p. 11–14.* (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2013.204.01.0011.01.ENG)

EC (European Commission), 2014 A. Common Methodology for State Aid Evaluation. *Commission Staff Working Document.* (http://ec.europa.eu/competition/state_aid/modernisation/state_aid_evaluation_methodology_en.pdf)

EC (European Commission), 2014 B. Commission Regulation (EU) No 651/2014 of 17 June 2014 declaring certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty Text with EEA relevance. *OJ L 187, 26.6.2014, p. 1–78.* (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0651&from=EN)

EC (European Commission), 2014 C. Communication from the Commission. Framework for State Aid for Research and Development and Innovation. *OJ C 198, 27.6.2014, p. 1–29.* (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XC0627(01)&from=EN)

EC (European Commission), 2014 D. Commission regulation (EU) No 651/2014 of 17 June 2014 declaring certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty. Off. J. Eur. Union L187, 1–87. (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0651&from=EN)

EC (European Commission), 2015 A. SA.40761 (2015/N) – Innovate UK (Technology Strategy Board) Research, Development and Innovation Scheme 2014 – Evaluation plan. (http://ec.europa.eu/competition/state_aid/cases/256732/256732_1703219_80_2.pdf)

EC (European Commission), 2015 B. Inventory of Union and Member State Incentives to Support Research into, and the Development and Availability of, Orphan Medicinal Products — State of Play. (https://ec.europa.eu/health/sites/health/files/files/orphanmp/doc/orphan_inv_report_20160126.pdf)

EC (European Commission), 2017. Case M.8425 - SAFRAN / ZODIAC AEROSPACE. (https://ec.europa.eu/competition/mergers/cases/decisions/m8425_715_3.pdf)

EC (European Commission), 2018. Boosting Electronics Value Chains in Europe, A Report to Commissioner Gabriel. (https://ec.europa.eu/digital-single-market/en/news/boosting-electronics-value-chains-europe)

EC (European Commission), 2019. Report from the Commission to the Council and the European Parliament Competition Enforcement in the Pharmaceutical Sector (2009-2017). (https://ec.europa.eu/competition/publications/reports/kd0718081enn.pdf)

EPO (European Patent Office), 2019. European Patent Statistics Annual Reports. (https://www.epo.org/about-us/annual-reports-statistics/statistics.html)

Eurostat, 2018. Gross domestic expenditure on R&D (GERD). (https://ec.europa.eu/eurostat/tgm/table.do?tab=table&plugin=1&language=en&pcode=t2020_20)

Grullon, G. et al., 2017. Are US Industries Becoming More Concentrated?

HMRC (HM Revenue & Customs), 2018 A. Research and Development (R&D) Tax Reliefs (https://www.gov.uk/guidance/corporation-tax-research-and-development-rd-relief)

HMRC (HM Revenue & Customs), 2018 B. Use a Venture Capital Scheme to Raise Money for Your Company. (https://www.gov.uk/guidance/venture-capital-schemes-raise-money-by-offering-tax-reliefs-to-investors)

HMRC (HM Revenue & Customs), 2018 C. Use a Venture Capital Scheme to Raise Money for Your Knowledge Intensive Company. (https://www.gov.uk/guidance/use-the-enterprise-investment-scheme-eis-to-raise-money-for-research-development-or-innovation)

House of Commons Business and Enterprise Committee, 2009. Risk and Reward: Sustaining a Higher Value-added Economy. *Eleventh Report of Session 2008-09 Volume I.* (https://publications.parliament.uk/pa/cm200809/cmselect/cmberr/746/746i.pdf)

House of Commons Committee on Exiting the European Union, 2017 A. Life Sciences Sector Report. (https://www.parliament.uk/documents/commons-committees/Exiting-the-European-Union/17-19/Sectoral%20Analyses/21-Life-Sciences-Report.pdf)

House of Commons Committee on Exiting the European Union, 2017 B. Aerospace Sector Report. (https://www.parliament.uk/documents/commons-committees/Exiting-the-European-Union/17-19/Sectoral%20Analyses/1-Sectoral-Analyses-Aerospace-Report.pdf)

House of Commons Committee on Exiting the European Union, 2017 C. Electronics and Machinery Sector Report. (https://www.parliament.uk/documents/commons-committees/Exiting-the-European-Union/17-19/Sectoral%20Analyses/13-Electronics-and-Machinery-Report.pdf)

IBIS World (2010) Electronic Component Manufacturing – UK Market Research Report. (https://www.ibisworld.co.uk/industry-trends/market-research-reports/manufacturing/manufacture-of-computer-electronic-optical-products/electronic-component-manufacturing.html)

Ipsos MORI, 2016 A. Advanced Propulsion Centre: Impact and Economic Evaluation Scoping. (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/499865/bis-16-125-apc-scoping-study.pdf)

Ipsos MORI, 2016 B. Biomedical Catalyst Evaluation: Process Evaluation and Baseline Impact Evaluation. (https://www.gov.uk/government/publications/the-biomedical-catalyst-an-evaluation-report)

Ipsos MORI, 2017 A. Strategic Investments in Low Impact Building: Impact Evaluation.

Ipsos MORI, 2017 B. Strategic Investments in Sustainable Agriculture and Food Evaluation.

Ipsos MORI, 2017 C. Evaluation of ATI Aerospace R&D Programme. Process and Implementation Review.

(https://www.gov.uk/government/publications/evaluation-of-ati-aerospace-rd-programme-process-and-implementation-review)

Ipsos MORI, 2018 A. Advanced Propulsion Centre: External Process Evaluation. *BEIS Research Paper 2018: Number 6.* (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/694754/APC_Evaluation_Report.pdf)

Ipsos MORI, 2018 B. ICURe Evaluation: Final Evaluation Report. (https://www.gov.uk/government/publications/icure-evaluation-of-pilot-programme)

IUK (Innovate UK), 2014. Toolset Manual Version 1.0.

IUK (Innovate UK), 2015. The Low Carbon Vehicles Innovation Platform: An Impact Review. (https://www.gov.uk/government/publications/the-low-carbon-vehicles-innovation-platform-an-impact-review)

IUK (Innovate UK), 2017 A. Delivery Plan: Shaping the future. (https://www.gov.uk/government/publications/innovate-uk-delivery-plan-2017-to-2018)

IUK (Innovate UK), 2017 B. Innovation Loans: An Overview of Innovate UK's Loan Programme for Smes Involved in Late-stage Innovation Projects. (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/676579/17.3215.185_Loans_Brochure_RatherNiceDesign_FINAL_Web.pdf)

IUK (Innovate UK), 2017 C. Ten Years Shaping the Future. (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/645036/10th_Anniversary_Brochure_WEB.pdf)

IUK (Innovate UK), 2018 A. Evaluation Framework. (https://www.gov.uk/government/publications/evaluation-framework)

IUK (Innovate UK), 2018 B. Launching the Compound Semiconductor Applications Catapult. (https://csa.catapult.org.uk/wp-content/uploads/2018/07/Launching-the-Compound-Semiconductor-Applications-Catapult.pdf)

IUK (Innovate UK), 2019. Delivery Plan 2019. (https://www.ukri.org/files/about/dps/innovate-uk-dp-2019/)

Mor, F., 2017. EU State Aid Rules and WTO Subsidies Agreement. *House of Commons Library Briefing Paper 06775*. (https://researchbriefings.parliament.uk/ResearchBriefing/Summary/SN06775#fullreport)

National Audit Office, 2013. Evaluation in Government. (https://www.nao.org.uk/wp-content/uploads/2013/12/10331-001-Evaluation-in-government_NEW.pdf)

OECD, 2017. Economic Survey of the United Kingdom 2017. (http://www.oecd.org/eco/surveys/economic-survey-united-kingdom.htm)

OECD, 2018. Gross Domestic Spending on R&D. (https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm)

ONS, 2009. UK Standard Industrial Classification of Economic Activities 2007 (SIC 2007). (http://www.siccodesupport.co.uk/)

ONS, 2019 A. Business Enterprise Research and Development, UK: 2017.

(https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/researchanddevelopmentexpenditure/bulletins/businessenterpriseresearchanddevelopment/2017/pdf)

ONS, 2019 B. UK Trade in Goods by Classification of Product by Activity Time Series. (https://www.ons.gov.uk/businessindustryandtrade/internationaltrade/datasets/uktradeingoodsbyclassificationofproductbyactivity)

Oxera, 2017. Ex Post Assessment of the Impact of State Aid on Competition. Final Report. (http://ec.europa.eu/competition/publications/reports/kd0617275enn.pdf)

PACEC, 2011. Evaluation of the Collaborative Research and Development Programmes: Final Report. (http://webarchive.nationalarchives.gov.uk/20130302042643/http://www.innovateuk.org/_assets/pacec_evaluation_of_crandd_report_final260911%20(2).pdf)

Resolution Foundation, 2018. Is Everybody Concentrating? (https://www.resolutionfoundation.org/publications/is-everybody-concentrating-recent-trends-in-product-and-labour-market-concentration-in-the-uk/)

Sherman, L.W., D.C. Gottfredson, D.L. MacKenzie, J. Eck, P. Reuter, P. and S.D. Bushway, 1998. Preventing Crime: What Works, What Doesn't, What's Promising. Research in Brief. *Washington, DC: National Institute of Justice*.

SQW, 2015. Evaluation of Smart: Impact and Process Evaluation. (https://www.gov.uk/government/publications/smart-funding-assessment-of-impact-and-evaluation-of-processes)

SQW, 2016 A. Evaluation of Smart: On-going Evaluation – Year 1 Report.

SQW, 2016 B. The Aerospace Technology Institute: Scoping Study to Establish Baselines, Monitoring Systems and Evaluation Methodologies. (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/499728/bis-16-123-ati-scoping-study.pdf)

SQW, 2017 A. Evaluation of Smart: On-going Evaluation – Year 2 Report.

SQW, 2017 B. Process Evaluation of the Catalyst Programmes: Scoping Paper.

SQW, 2017 C. Process Evaluation of the Catalyst Programmes: Interim Progress Report.

SQW, 2018 A. Review of Innovate UK's Connect KTN Activities. Draft Final Report to Innovate UK.

SQW, 2018 B. Evaluation of Innovation Loans: Summary Findings from Early Review of Non-applicants.

SQW, 2019 A. Evaluation of Innovation Loans: Early Interim Report.

SQW, 2019 B. Evaluation of Smart: Ongoing Evaluation Final Report.

SQW, 2019 C. Investment Accelerator Pilot Evaluation: Interim Impact Report.

SQW, 2019 D. Process Evaluation of the Catalyst Programmes: A Final Report to Innovate UK (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/791302/IUK_-_Catalyst_process_evaluation_-_FINAL_Report_24_May__edit_27_Sept__for_publication.pdf)

The Economist, 2016. Too Much of a Good Thing (https://www.economist.com/briefing/2016/03/26/too-much-of-a-good-thing)

UK Data Archive, 2006. Business Structure Database User Guide. (http://doc.ukdataservice.ac.uk/doc/6697/mrdoc/pdf/6697_user_guide.pdf)

Valletti, T., G. Koltay, S. Lorincz and H. Zenger, 2017. Concentration Trends in Europe

WECD, 2013. TSB Feasibility Studies Programme: Evaluation Findings. (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/626872/TSB_Feasibilty_Studies_Programme_-_Evaluation_Findings_2013.pdf)

Wong, C.H., K.W. Siah, and A.W. Lo, 2019. Estimation of Clinical Trial Success Rates and Related Parameters. *Biostatistics*, *20*(2), pp.273-286.

WTO (World Trade Association), 1995. Agreement on Subsidies and Countervailing Measures.
(https://www.wto.org/english/docs_e/legal_e/24-scm.pdf)

WTO (World Trade Association), 2010. European Communities and Certain Member States — Measures Affecting Trade in Large Civil Aircraft.
(https://www.wto.org/english/tratop_e/dispu_e/cases_e/ds316_e.htm)

WTO (World Trade Association), 2011. European Communities and Certain Member States — Measures Affecting Trade in Large Civil Aircraft. Report of the Appellate Body
(https://www.wto.org/english/tratop_e/dispu_e/316abr_e.pdf)

ANNEX A ADDITIONAL DETAIL ON EVIDENCE SYNTHESIS

A.1 Maryland Scientific Methods Scale (SMS)

In Figure 94 below we outline what type of studies are included under each category within the SMS.[226]

Figure 94 Maryland Scientific Methods Scale description

Level 1	Evaluation assesses outcomes after an intervention but only for those affected. No comparison groups are used.
Level 2	Evaluation compares outcomes before and after an intervention, or makes a comparison of outcomes between groups or areas that are not matched.
Level 3	Comparison between two or more comparable groups/areas, one with and one which does not receive the intervention.
Level 4	Use of statistical techniques to ensure that the programme and comparison group were similar and so fair comparison can be made.
Level 5	Random assignment and analysis of comparable units to programme and comparison groups.

Source: Sherman et al., (1998). National Audit Office (2013)

[226] The levels used in this report come from the What Works Centre for Local Economic Growth who have adapted the original scale slightly.

A.2 List of existing evaluation reports included within our evidence synthesis

Figure 95 Documents reviewed

Document title	Relevant programme
Evaluation of Smart: Impact and Process Evaluation (SQW, 2015)	Smart
Evaluation of Smart: On-going Evaluation – Year 1 Report (SQW, 2016 A)	Smart
Evaluation of Smart: On-going Evaluation – Year 2 Report (SQW, 2017 A)	Smart
Evaluation of Smart – On-going Evaluation – Final Report (SQW, 2019 B)	Smart
Process Evaluation of the Catalyst Programmes: Scoping Paper (SQW, 2017 B)	Catalysts
Process Evaluation of the Catalyst Programmes: Interim Progress Report (SQW, 2017 C)	Catalysts
Process Evaluation of the Catalyst Programmes: A Final Report to Innovate UK (SQW, 2019 D)	Catalysts
ICURe Evaluation: Final Evaluation Report (Ipsos MORI, 2018 B)	ICURe
Evaluation of the Collaborative Research and Development Programmes: Final Report (PACEC, 2011)	CR&D
Strategic Investments in Low Impact Building: Impact Evaluation (Ipsos MORI, 2017 A)	CR&D
Strategic Investments in Sustainable Agriculture and Food Evaluation (Ipsos MORI, 2017 B)	CR&D
The Low Carbon Vehicles Innovation Platform: An Impact Review (IUK, 2015)	CR&D
TSB Feasibility Studies Programme: Evaluation Findings (WECD, 2013)	CR&D
Advanced Propulsion Centre: External Process Evaluation (Ipsos MORI, 2018 A)	CR&D
Advanced Propulsion Centre: Impact and Economic Evaluation Scoping (Ipsos MORI, 2016 A)	CR&D

Document title	Relevant programme
The Aerospace Technology Institute: Scoping Study to Establish Baselines, Monitoring Systems and Evaluation Methodologies (SQW, 2016 B)	CR&D
Evaluation of ATI Aerospace R&D Programme. Process and Implementation Review (Ipsos MORI, 2017 C)	CR&D
Evaluation of Innovation Loans: Summary Findings from Early Review of Non-applicants (SQW, 2018 B)	Innovation Loans Pilot
Evaluation of Innovation Loans: Early Interim Report (SQW, 2019 A)	Innovation Loans Pilot
Investment Accelerator Pilot Evaluation: Deliverable 3 Interim Impact Report (SQW, 2019 C)	Investment Accelerator Pilot

Source: Frontier

Note: Internal IUK documents were also reviewed as part of the evidence synthesis

ANNEX B QUALITATIVE RESEARCH SUPPORTING MATERIALS

B.1 List of organisations engaged with

Figure 96 List of organisations interviewed

Organisation	Relevant market	Role
Spirit AeroSystems	Manufacture of air and spacecraft	Funding applicant
Airbus	Manufacture of air and spacecraft	Funding applicant
Aerospace Technology Institute	Manufacture of air and spacecraft	Industry association/funder
Department for Business Energy and Industrial Strategy	Manufacture of air and spacecraft	Funder
Autifony Therapeutics	R&D on biotechnology	Funding applicant
Cyclacel	R&D on biotechnology	Funding applicant
Oxford Biomedica	R&D on biotechnology	Funding applicant
Cancer Vaccines	R&D on biotechnology	Funding applicant
BioIndustry Association	R&D on biotechnology	Industry association
Oxsonics	Manufacture of medical and dental instruments	Funding applicant
Kimal	Manufacture of medical and dental instruments	Funding applicant
Momentum Bioscience	Manufacture of medical and dental instruments	Funding applicant
Biomedical Catalyst	Manufacture of medical and dental instruments	Funder
Dynex Semiconductor	Manufacture of electronic components	Funding applicant
MSF Technologies	Manufacture of electronic components	Funding applicant
PragmatIC Printing	Manufacture of electronic components	Funding applicant

Organisation	Relevant market	Role
Centre for Power Electronics	Manufacture of electronic components	Industry association

B.2 Example topic guide

B.2.1 Background

- What activities does your organisation carry out in the UK vs. the rest of Europe?
- What is your role within your organisation?
- Who are your main suppliers and customers?
- Talk us through the supply chain for your industry.

B.2.2 Competitive space

- What sort of businesses do you view as your key competitors?
    - What's the nature of the competition? How do you differentiate yourselves from competitors?
    - How does this vary at different levels of the supply chain?
- How has the competitive landscape evolved over time?
- What are the barriers to entry?
- What role does R&D play in your industry?
- How is IUK viewed within the market?

B.2.3 IUK project(s)

- How did you come into contact with IUK?
- In general, why do you apply for IUK funding?
- Could we discuss a specific project in depth?
- For this project/these projects could you describe
    - What were the project objectives?
        - Development of new product/processes
        - Development of IP
        - Enter new markets or increase market share
        - Displace existing firms
        - Increase in efficiency
        - What is the level of risk
        - Maintain existing operations
    - Collaboration
    - Other sources of match funding
    - If IUK did not provide funding what would you have done?
    - Closeness of project to market

- Was this project quite different from the kind of R&D projects that you might fund internally?
- Could you have carried out this work outside of the UK?
  - Why was the UK chosen?
- What happens after the project is complete?
  - Sale of IP/licensing?
  - How are learnings disseminated?
- Have you ever applied unsuccessfully for IUK support?
  - Were there any benefits of going through that process?