OXFORD ECONOMICS

The impact of the innovation, research and technology sector on the UK economy

November 2014

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Contents

1 Study overview and conclusions

The innovation, research and technology (IRT) sector has developed and grown considerably since the last impact study, which was concerned with the situation in 2006. With new entrants such as the Catapult Centres there is a renewed focus on the sector and a growing dynamism driving forward its activities. AIRTO (the Association for Innovation, Research and Technology Organisations) has commissioned this study to measure the impact of the sector on the UK economy and to understand better the make-up of the work being undertaken.

This study quantifies the total economic impact of the innovation, research and technology sector on the UK economy in 2012/13. A comprehensive understanding of the sector's core impacts (including the impact of the sector itself, its supply chain impacts and wage-consumption impacts) as well as its extended impacts (such as spillover returns to R&D, increased UK investment attractiveness, and an improved skills base) has been produced, showing its importance for the future development of the UK economy.

There are significant findings for policymakers, public stakeholders and AIRTO members. Policymakers will find that the IRT sector is a cornerstone of innovation in the UK, and that while the current level of public support for the sector is minimally burdensome at 0.3% of total UK government spending, that modest level of support is extensively leveraged. The wider public will see examples of the IRT sector improving quality of life in the UK and successfully helping new, innovative products and services reach commercial availability. AIRTO's members will learn that their membership organisation has grown during the deepest recession since the Second World War, now accounts for 80% of the IRT sector, and has an aggregate turnover 3.7 times as large as the Fraunhofer network, although AIRTO members span a significantly wider range of activities.

Oxford Economics quantified the impacts of the IRT sector through three comprehensive methods. First, the study uses data from IRT organisations themselves, including financial statements and detailed survey responses from AIRTO members, to quantify the employment, gross value added, and tax contributions of the sector itself. Next, the study employs a customised impact model of the UK economy to map the sector's supply-chain linkages and employee wage impacts. Finally, AIRTO members' survey responses were combined with leading research from Oxford Economics and others to quantify, where possible, the wider impacts, such as R&D spillovers and improved skills for the UK workforce.

This study finds that the 'core' impacts of the IRT sector are substantial. Based on £6.9 billion in turnover in 2012/13, the sector directly generated £3.7 billion in gross value added contributions to UK GDP. Furthermore, the sector directly employed 57,200 people and paid an estimated £1.4 billion in tax. Over the same time period, after accounting for supply chain and wage-consumption impacts the sector is estimated to have supported £7.6 billion in gross value added, 140,100 jobs (similar to total employment in Milton Keynes) and £2.9 billion in tax receipts.

The wider, or 'catalytic', impacts of the sector are larger still. Private and spillover benefits from the sector's R&D activity alone are estimated at £9.8 billion on the basis of a standard analysis, and are probably higher in practice due to the nature of the sector's activity. Finally, this study estimates that the IRT sector supports a host of harder to quantify impacts related to investment attractiveness in the UK and skills development, which may be valued in the range of £14.5-18.5 billion. On this basis the sector's contribution to the economy through the catalytic channels would be over three times the contribution through the direct, indirect and induced channels – an unusually high ratio demonstrating the sector's almost unique position in the economy.

Summing across all these impacts, Oxford Economics estimates that the contribution of the IRT sector to the UK economy is plausibly in the range of £32-36 billion. That is equivalent to 2.3-2.6% of total UK gross value added in 2012/13.

The sector's contribution implies a unique opportunity for government leverage. Government can continue to fund the IRT sector at a low burden to the taxpayer while having a high impact on IRT organisations looking to replenish their physical and intellectual capital. It can leverage the sector's impact by procuring innovative products and services, effectively pulling them into mainstream use.

And it can address a critical shortage of skills needed within the sector and elsewhere by promoting opportunities for STEM-related career paths in RTOs, and within PSREs (Public Sector Research Establishments) in particular which have not had a high profile in Government awareness campaigns in recent times.

1.1 Other key points

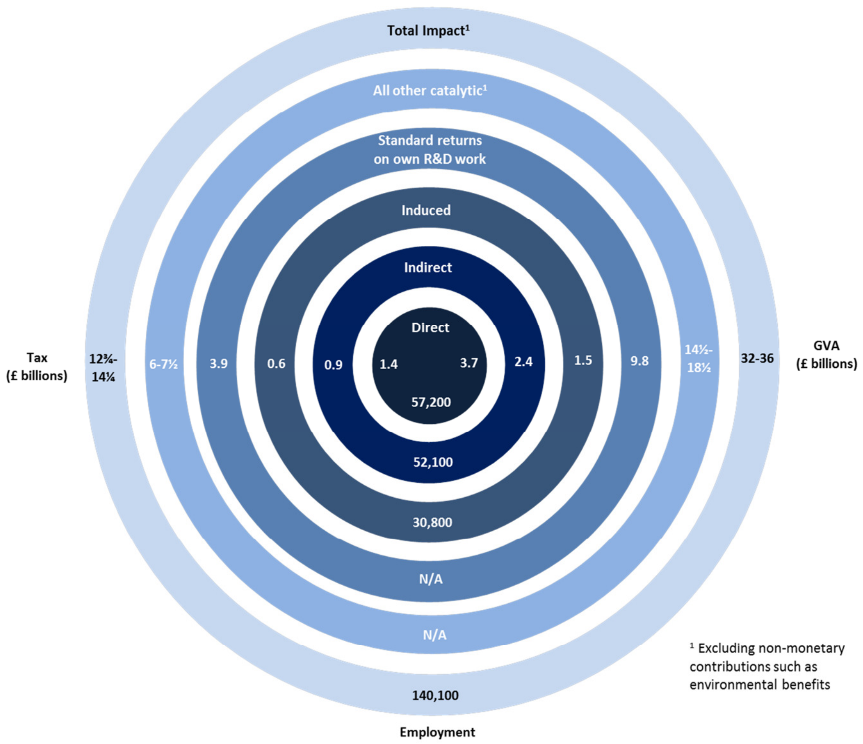
- **The innovation, research and technology (IRT) sector comprises organisations that help turn ideas, wherever they come from, into successful products and services, which are then put into use by industry, business and government.** In doing so, IRT organisations amplify the take-up of technology, seeking to reduce development costs, accelerate time to market, and enhance the prospects for innovation success. Furthermore, the sector acts as a critical link between academia, other research institutions, industry and business in the UK.
- **The sector is highly productive**. On average, each employee generated £64,100 in gross value added per year in 2012/13. That is up 18% in money terms since 2006, or around 3% in real (inflation adjusted) terms, whereas real productivity for the economy as a whole was essentially unchanged in that time. To put the sector's productivity in context, it is 45% higher than the UK average in 2013. It is also higher than in the UK architectural services sector (£53,000), market research and public opinion polling sector (£50,400), the scientific research and development sector as a whole (£46,500), and the technical testing and analysis sector as a whole (£40,300).
- **The IRT sector supports a substantial number of jobs**. The sector itself employed an estimated 57,000 people in 2012/13. That is similar to the number of full time academic staff at the Russell Group of Universities in the UK. Including direct, indirect and induced impacts, the IRT Sector supported an estimated 140,100 jobs in 2012/13, similar in magnitude to total employment in Milton Keynes. That is one in every 230 jobs in the UK.
- **AIRTO's members now account for four fifths of the IRT sector's turnover.** Emerging from the deepest recession since the Second World War, AIRTO's membership has grown to include a larger share of the IRT sector. In addition, AIRTO has a similar number of members to the Fraunhofer network in Germany. AIRTO members' turnover is in aggregate 3.7 times as large as that of the Fraunhofer network, although it should be noted that the former engage in a considerably wider range of activities.

2 Full summary of findings

The innovation, research and technology (IRT) sector generates significant economic activity in the UK

- Turnover in the IRT sector is estimated to have been £6.9 billion in 2012/13.
- In total, through its direct, indirect and induced impacts, the IRT sector supported an estimated £7.6 billion in gross value added for the UK economy in 2012/13.
- The IRT sector has a gross value added multiplier of 2.08. So for every £1 million of GVA created in the sector itself, another £1.08 million is supported in other sectors of the UK economy.
- Through its direct, indirect and induced impacts, the IRT sector supported an estimated 140,100 jobs in 2012/13. That is one in every 230 jobs in the UK.
- The IRT sector has an employment multiplier of 2.4. Thus, for every 100 people employed in the sector itself, another 140 jobs are supported elsewhere in the UK economy.
- Total employment supported in the IRT sector in 2012/13 was similar in magnitude to total employment in Milton Keynes.
- The IRT sector's productivity, at £64,100 gross value added per employee per year, was 45% higher than the UK average in 2013. It is also higher than in the UK architectural services sector (£53,000), market research and public opinion polling sector (£50,400), scientific research and development sector as a whole (£46,500), and technical testing and analysis sector as a whole (£40,300). It is estimated that productivity in the IRT sector has risen by 3% in real (inflation adjusted) terms since 2006, whereas real productivity across the economy as a whole was essentially flat.

Figure 2.1: Total economic impact of the IRT sector overall



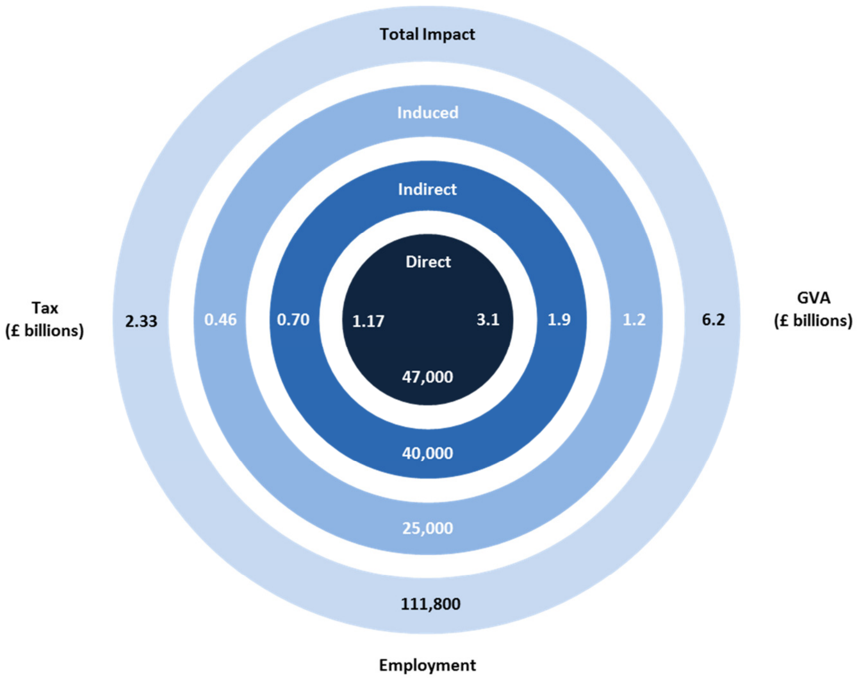
Resulting tax receipts for the Exchequer are substantial

- The IRT Sector generated an estimated £2.9 billion in tax receipts in 2012/13, as a result of the direct, indirect and induced activity supported.
- This tax contribution would have been sufficient to fund the wages of 41,000 doctors, 89,000 teachers or 111,000 nurses.

AIRTO members now account for 80% of the IRT sector's turnover

- AIRTO members now account for four fifths of the IRT sector's turnover. This is due to AIRTO's membership growth and increased turnover of existing members. AIRTO itself now has a wider reach, but note that for the purposes of this study the definition of the sector previously used (for 2006) remains the same.
- AIRTO members directly employed nearly 47,000 people in 2012/13, and generated a £3.1 billion gross value added contribution to UK GDP.
- Between 2006 and 2012/13, AIRTO's membership grew from 34 to 56, and turnover among members has grown to £5.5 billion.
- AIRTO has a similar number of members to the well-known Fraunhofer network in Germany. AIRTO members' turnover is 3.7 times as large and they employ 2.1 times as many people, although their range of activities is considerably wider.

Figure 2.2: Total 'core' economic impact of AIRTO members



AIRTO members earn 34% of revenues from the private sector, with two thirds of revenues sourced from UK-based customers or funders, although patterns of business vary widely between organisations

- Oxford Economics' survey of AIRTO members found that members earn 67% of their revenue from customers or funders in the UK. The EU (10%) and rest of the world (23%) account for the remainder.

- Private sector operations account for 34% of AIRTO members' turnover. Of that, three quarters is generated from large firms, while one quarter is generated from small and medium sized enterprises (SMEs).
- UK government core funding accounts for 26% of sector turnover, and competitively-tendered UK government contracts for a further 25%. These figures are dominated by the Public Sector Research Establishments (PSREs) in membership.
- AIRTO members employ people in each of the UK's twelve nations and regions. Just under half (48%) are located in London or the South East. Thirteen per cent are located in the South West, 10% in the West Midlands and 8% in the North West. Yorkshire and the Humber, the East of England, the East Midlands, Scotland, Wales, the North East, and Northern Ireland account for a combined 21%.

The IRT sector also generates significant benefits for clients and third parties through R&D and other project work…

- If recent volumes of IRT organisations' R&D activity were maintained, then on the basis of Oxford Economics' 'standard' estimation the private return for clients from this work alone would eventually settle at £3.5 billion per annum at today's prices.
- The spillover return from this R&D activity would be an even more significant £6.3 billion per year on the same basis.
- In practice, the private and spillover returns to R&D work are likely to be greater still, as these returns are typically above-average in the fields in which IRT organisations tend to operate.
- Case studies show significant commercial benefits for clients being achieved in practice, consistent with the above thesis and also with the existence of significant client returns from IRT organisations' non-R&D project work.

… with additional monetary returns generated through three catalytic channels:

- Enhancing spillover returns to R&D
    - Other ways in which IRT organisations generate value added for the UK economy include facilitating others to undertake R&D and enhancing private and spillover returns generated by others' R&D.
    - This is achieved by collaborative work with universities and networking across the academic, government and business sectors (e.g. through knowledge transfer activities), as well as by facilitating collaboration on projects between third party businesses in high-potential sectors (e.g. at technology parks).
- Increasing the UK's investment attractiveness
    - The IRT sector increases the UK's attractiveness for investment by multinational firms (foreign and UK-owned) through productivity-enhancing, innovative projects and by working with Local Enterprise Partnerships for example.
    - Research indicates that such multinational investment can bring significant net benefits to an economy. This report explores real-life case study examples of high-productivity, high-pay roles being created as a result of multinationals locating new productive facilities in the UK following collaborative work with IRT organisations on process innovation.

- Developing the UK's skills base
  - The sector also helps to develop the UK's skills base through its employment of highly-qualified staff in relevant jobs, by offering work experience posts to graduate students and others, through engagement with schools, and through the provision of apprenticeships and other staff training.
  - Research supports the view that work experience, apprenticeships and other training generate significant positive returns for the individuals concerned, for employers and future employers, and for others including co-workers.

The sector's total contribution to UK GVA and tax receipts is therefore substantial…

- Aside from the 'standard' calculation of client and spillover returns from IRT organisations' own R&D activity, it is not possible to robustly quantify the impact on GVA of these catalytic channels.
- However, other research suggests that for every £1 of public money spent in science-related fields, the overall return to the wider economy is in the range of £4 - £7. Taking this into account we can tentatively suggest that the sector's overall contribution to monetary GVA – including through the catalytic channels – is in the range of £32-36 billion, or 2.3%-2.6% of total UK GVA.
- On this basis the sector's contribution to the economy through the catalytic channels would be over three times the contribution through the direct, indirect and induced channels – an unusually high ratio demonstrating the sector's almost unique position in the economy.
- Tax receipts associated with that would be in the range of £12¾-£14¼ billion per annum, sufficient to cover the entire budget of either the Department of Transport or the Home Office. However as most of the catalytic channels act on productivity but not employment, it is not clear that total jobs supported would be significantly higher than the 140,100 provided by the direct, indirect and induced channels alone.

… as are other important non-monetary contributions to society

- On top of all of this, there are many real-life examples of IRT organisations making contributions to the achievement of public welfare goals, in fields such as the environment, health, safety and quality of life.
- As these are non-monetary contributions to society we have not attempted to include them in the sector's contribution to monetary GVA, but their significance is demonstrated in some of the case studies included in this report.

The sector achieves all of this with only modest public funding…

- Translating research and innovation into tangible products and services is both costly and risky. The benefits to UK citizens often translate into impact only years or even decades later; they are also rarely confined to the firm or research institution conducting the original research and instead spill over to society at large. For these reasons total reliance on private sector investment in research and innovation will be sub-optimal for the economy as a whole. This is often referred to as market failure, and justifies continued support from the public purse.

- Yet IRT organisations receive only very modest public funding. Based on the survey of AIRTO members by Oxford Economics, little more than £2 billion, or 0.3% of total government expenditure, is allocated to the IRT sector, leaving the burden of risk heavily biased towards the private sector. This may act as a brake on the pace of transferring innovation into the economy as a whole.
- Additional government funding to the point where private finance has the confidence to take over could mitigate some of this risk. This would help the UK to better exploit new innovations and leading edge technologies and boost the potential returns to UK plc. BIS priority sectors[1] should be a focus, as the potential for spillover benefits for society as a whole is greatest in such areas of activity.

Maximising the impact of the innovation, research and technology sector requires strengthening collaboration between government, academia and industry…

- Collaborative and strategic partnerships between academia, public services and industry are crucial to enhance the two-way flow of knowledge between those groups. These activities accelerate the speed with which new products and services can get to market, and thus help to ensure that the UK has 'first-mover advantage'.
- Ways in which the Government can leverage the impact of the IRT sector include:
    - Continuing to fund the sector at current levels. This would allow organisations in the sector to replenish their physical and intellectual capital as established technologies are transferred to industry.
    - Targeting public sector procurement to pull innovation products and services into everyday use.
    - Continuing to focus on skills that strengthen innovation capabilities. That includes promoting opportunities for STEM-related career paths in RTOs and within PSREs.

… and it follows that modest additional funding would generate meaningful net economic benefits

- Further survey results show a positive relationship between IRT organisations' desired capital expenditure and their ability to expand activities over a five-year horizon, with respondents identifying a range of financial and other barriers potentially preventing that desired capital spending from going ahead.
- These respondents see additional public funding, amongst other policy options, as a way of removing some of the perceived barriers to growth in activity.
- These results, together with the evidence of significant spillover benefits from the existing level of public funding, suggest that modest additional core funding for parts of the IRT sector could be expected to generate significant additional benefits for the UK economy.

[1] Including Life Sciences, Nuclear, Information economy, Aerospace and defence, Oil and gas, Construction, Professional business services, Automotive, Agri-tech, Education and Offshore wind, each of which is expected by the Government to make an above-average contribution to UK growth going forward.

3 Background to the study

This is an independent study of the impact of the innovation, research and technology (IRT) sector's impact on the UK economy in 2012/13. Commissioned by the Association for Innovation, Research and Technology Organisations (AIRTO), this report updates and expands on an earlier Oxford Economics study published in 2008 and concerned with the sector's impact in 2006[2]. It is intended to inform both internal and external stakeholders of the activities and impacts of the people, companies and organisations[3] in the IRT sector.

Oxford Economics' previous report demonstrated that the IRT sector – and AIRTO's membership – made a substantial contribution to UK jobs and GDP[4]. For example, through its direct, indirect, and induced impacts, the sector was estimated to have supported 62,000 jobs and £2.4 billion in gross value added[5] (GVA) contributions to UK GDP in 2006. AIRTO's members accounted for approximately half of that impact. Furthermore, the IRT sector was identified as having a range of wider benefits, including the enhancement of research and development spillover effects, facilitating the exploitation of research and development, and improving market efficiency by overcoming information gaps.

Much has changed since 2006: AIRTO's membership, made up of 56 organisations at the time of the survey underlying this report's analysis[6], has expanded to include a greater share of the IRT sector as measured by turnover and new types of organisation have joined; the sector itself has seen some key firms grow in scale while others have contracted, merged or even ceased trading; the UK economy has entered and emerged from the most significant recession since the Second World War; and the public discussion of the government's role in the innovation sector has evolved along with the way the sector interacts with government.

In the midst of these changes, it is clear that the innovation, research and technology sector's role in the UK economy remains significant and has even grown in importance. Organisations that innovate, or bridge the gap between ideas and their implementation in industrial or commercial spheres, or which specialise in networking with public and private entities, are vital to increasing the productive potential of the UK economy. Consider these three diverse examples of IRT organisations' successful initiatives:

- The Advanced Manufacturing Research Centre (AMRC), which is one of the High Value Manufacturing Catapult's core establishments and an AIRTO member, recently partnered with Rolls-Royce to cut manufacturing time for high-stress fan and turbine discs by 50%. The partnership also resulted in a step-change improvement in component performance. The introduction of robotics and

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[2] Oxford Economics, (2008), 'Study of the impact of the intermediate research and technology sector on the UK economy'.

[3] Organisation types include private or publicly limited companies, universities and other publicly owned institutions, and non-profits and companies limited by guarantee.

[4] GDP is the most widely used measure of economic activity in the UK. It measures the market value of goods and services sold within the country, and is used to describe the rate of growth of an economy as well as when it enters or exits a recession.

[5] Gross value added (GVA) is used to measure the contribution to GDP for a company or industry. Across the whole economy, GVA plus taxes on products less subsidies on products is equal to GDP (ONS).

[6] As of June 2014. Since 2006, 33 organisations had joined, while 11 organisations were no longer members. Since June (as of 1 November 2014), a further three members have joined while five have left.

automation, and the use of the latest advanced process platforms, was central to this achievement.

- Pera Technology, an AIRTO member drawing on Seventh Framework Programme funding, successfully managed a project involving seven public and private sector organisations from across Europe to develop the 'Trem-End'. The Trem-End is an innovative, cost-effective, and commercially available medical appliance for wrist tremor suppression. It reduces obtrusiveness and increases tremor suppression efficacy compared with current solutions.
- The Institute for Sustainability (IfS, also an AIRTO member) is a charity set up in 2009 to support cross-sector collaboration and innovation. Alongside Imperial College London, the IfS acts as UK lead on several projects funded by the Climate Knowledge and Innovation Community (Climate-KIC); the management of Sustainable Innovation Forums is one such project. Recent initiatives include the promotion of behaviour change pilots in multi-tenanted buildings, and challenge-led competitions to find innovative photovoltaic (PV) and building metering and monitoring technologies.

These, and other initiatives that will be discussed in this report, exemplify the significant – and growing – role of the IRT sector in the UK economy. In light of the changes that the sector has experienced since 2006, this report presents a fresh look at the total economic impact that AIRTO members and the IRT sector had on the UK economy in 2012/13.

A glossary of terms used throughout this report:

Report Glossary

AIRTO – Association for Innovation, Research and Technology Organisations.

CLG – Company limited by guarantee. This type of company does not have share capital and its members are guarantors, not shareholders. Often referred to as 'non-profit' organisations in this report.

GDP – Gross domestic product. This concept measures the market value of goods and services sold within a country, and is used to assess the rate of growth of an economy as well as when it enters or exits a recession.

GVA – Gross value added. The concept is used to measure the contribution to a country's GDP of a company or industry.

IRT – Innovation, research and technology.

LEP – Local Enterprise Partnership.

PSRE – Public Sector Research Establishment.

PLC – Public limited company. This type of company has share capital and limits the liability of each member to the amount of their shares.

RTO – Research and technology organisation.

TRL – Technology readiness level. This concept operates on a scale from one to nine, where nine represents full production.

The rest of this report proceeds as follows:

- **Section 4** defines the role of the innovation, research and technology (IRT) sector.
- **Section 5** discusses the objectives, conduct and methodology of this study.
- **Section 6** quantifies the size and economic contribution of the IRT sector. This includes jobs, GVA and tax receipts supported by the sector.
- **Section 7** presents the wider benefits of the IRT sector.
- **Section 8** discusses the minimal, yet highly beneficial, role of public funding in the IRT sector.
- **Section 9** concludes and discusses the validity of six plausible hypotheses about the size, role and potential development of the IRT sector within the UK.

These sections are designed to stand alone and therefore the reader will find some information repeated where relevant to the section concerned.

4 Definition and role of the innovation, research and technology sector

Definition and role of the IRT sector

The innovation, research and technology (IRT) sector is made up of organisations and companies that supply professional services vital for innovation. This includes a range of organisations that help turn ideas into successful products and services, including underpinning them with necessary research, technology and business support. Such products and services are then put into use by industry, business and government. While some firms are dedicated to research and development or technology translation and adaptation, others are engaged in testing and proving, or in the management and financing of these activities.

Figure 4.1 shows that the innovation, research and technology sector plays a vital role in accelerating the take-up of technology. In some circumstances, this involves the industry communicating its needs to government, funding bodies, academic institutions and other IRT organisations. Elsewhere, the sector transmits information about the existence and relevance of new, innovative research to industry players.

The IRT sector, therefore, is a critical link between academia, other research institutions and industry. In that capacity, it increases technology readiness levels (TRLs)[7] in the UK. The sector typically has the greatest influence between TRLs 4 and 7, achieving its goals via risk reduction – whether the risk in question is technology risk, market risk, or the risk of financial failure. This process is often non-linear: instead of simply shepherding a technology from one level to the next, companies in the IRT sector often need to move nimbly between TRLs.

At its best, the IRT sector has the potential to enhance UK productivity, increase international competitiveness of UK research and industry, attract and train a highly-skilled workforce, and, ultimately, improve quality of life in the country.

Scope of the IRT sector

This study uses the same definition of the IRT sector that was used in Oxford Economics' 2008 report (relating to the 2006 position), comprising:

- **AIRTO's membership** – the 56 companies in membership as of June 2014, shown later in Table 6.1.
- Over **170 companies** selected by AIRTO from the following two ONS standard industrial classification (SIC 2003[8]) categories: **Technical testing and analysis** (SIC 74.3) and **Research and experimental development on natural sciences and engineering** (SIC 73.1).
- **Three Catapults that are not already AIRTO members[9]**, namely Cell Therapy, Offshore Renewable Energy, and Future Cities.

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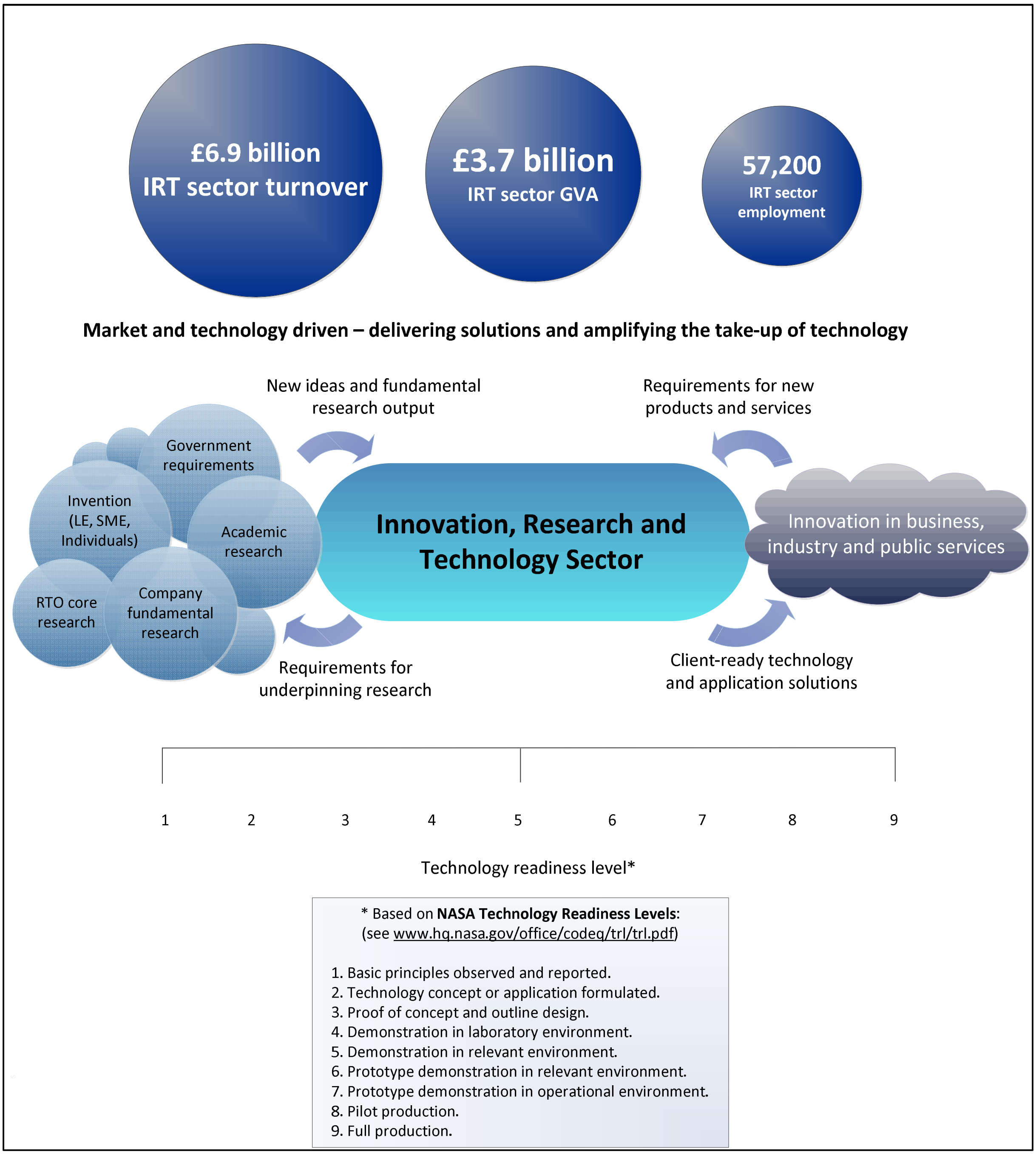
[7] Mankins, J. (1995), 'NASA Technological Readiness Levels'.

[8] ONS, (2002), 'Standard Industrial Classification of Economic Activities 2003'.

[9] The other four Catapults are AIRTO members, namely Connected Digital Economy Catapult, High Value Manufacturing Catapult, Satellite Applications Catapult, and Transport Systems Catapult.

Figure 4.1: Overview of the size and role of the innovation, research and technology sector in the UK in 2012/13



Who are AIRTO's members and what do they do?

Many companies and organisations in the IRT sector are also members of the Association for Innovation, Research, and Technology Organisations (AIRTO). In fact, AIRTO's membership comprises approximately 80% of the IRT sector's turnover.

AIRTO members provide contract and collaborative R&D, consultancy, knowledge and technology transfer, licensing, testing and certification, standards, training and generic research, as well as the management and financing of such activities.

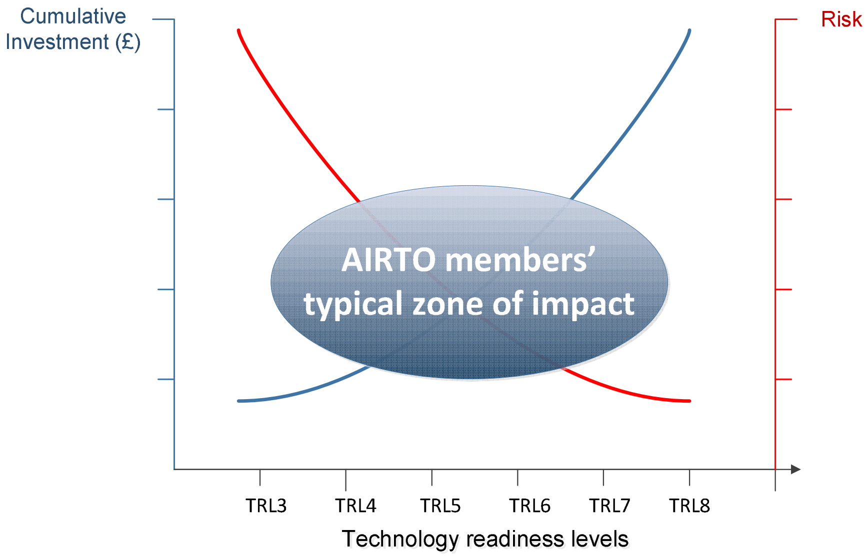
While diverse in day-to-day activities, AIRTO members are all:

- Market and client led;
- Commercial and business like (customer focused); and
- Professional, objective, and skilled at applying technology and technical insight.

AIRTO members include Public Sector Research Establishments (PSREs); non-profit distributing member and non-member based research and technology organisations (RTOs); privately held research and technology companies (including Contract Research Organisations or CROs); university enterprise/technology transfer departments; research and development departments of industrial companies; business support organisations (including those offering access to finance support); and Catapults (an Innovate UK[10] initiative to drive innovation in the UK). These organisations are often collectively referred to as IRT organisations in this report[11].

Schematic 4.2 illustrates where AIRTO's typical 'zone of impact' lies. As a research concept interacts with the technology readiness chain, the cumulative investment in it increases. As this occurs, AIRTO members seek to reduce the risk inherent in any technology innovation, application or research and development venture.

Schematic 4.2: Illustration of AIRTO members' area of impact



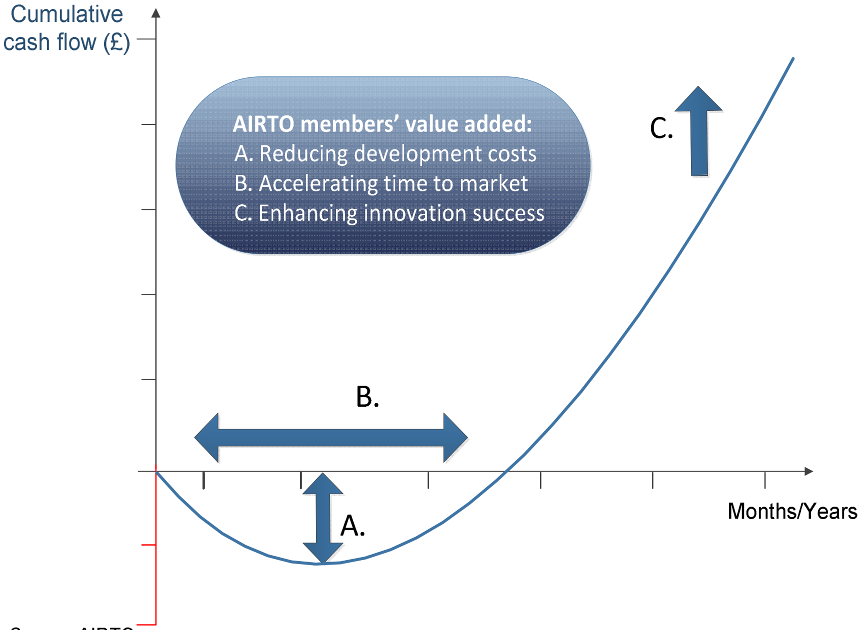
Source: AIRTO

[10] Innovate UK is the BIS-sponsored agency previously known as the Technology Strategy Board (TSB).

[11] This economic impact study covers many of the organisations within the IRT sector, as defined above in 'Scope of the IRT sector', although it will not have captured all of them.

Schematic 4.3 illustrates how AIRTO members add value to projects: they seek to reduce development costs, accelerate time to market, and ultimately enhance the prospects for innovation success.

Schematic 4.3: Illustration of AIRTO members' value added



Source: AIRTO

5 Objectives, conduct and methodology of the study

The objective of this report is to quantify and discuss the economic impact of the IRT sector[12] on the UK economy in 2012/13. That includes the standard, or 'core', economic impact of the IRT sector; the wider, or 'catalytic', benefits of the IRT sector; and an assessment of six hypotheses for how the IRT sector promotes, enables, and enhances innovation in the UK economy.

In conducting the study, Oxford Economics relied on three tools: financial statement analysis, Input-Output modelling[13], and a detailed survey of AIRTO members. The following discusses the use of each of these methods in key sections of the report.

5.1 Standard economic impact analysis

Section 6.1 of this report assesses the standard economic impact of the IRT sector, which is measured across three metrics:

- **The gross value added (GVA)** contribution to the UK economy;[14]
- **Employment** measured on a headcount basis;[15]
- **Tax receipts** generated for the Exchequer.

The sector's impact on the economy flows from three types of expenditure (see Figure 5.1). These are:

- **Direct impacts** – the economic activity created at IRT members' establishments through their operational expenditure.
- **Indirect (or supply chain) impacts** – these impacts occur as a result of IRT organisations' expenditure on inputs of goods and services in their UK-based supply chain.
- **Induced (or wage consumption) impacts** – these impacts arise from IRT employees and those employed in their direct supply chain spending their wage income on goods and services in the UK economy.

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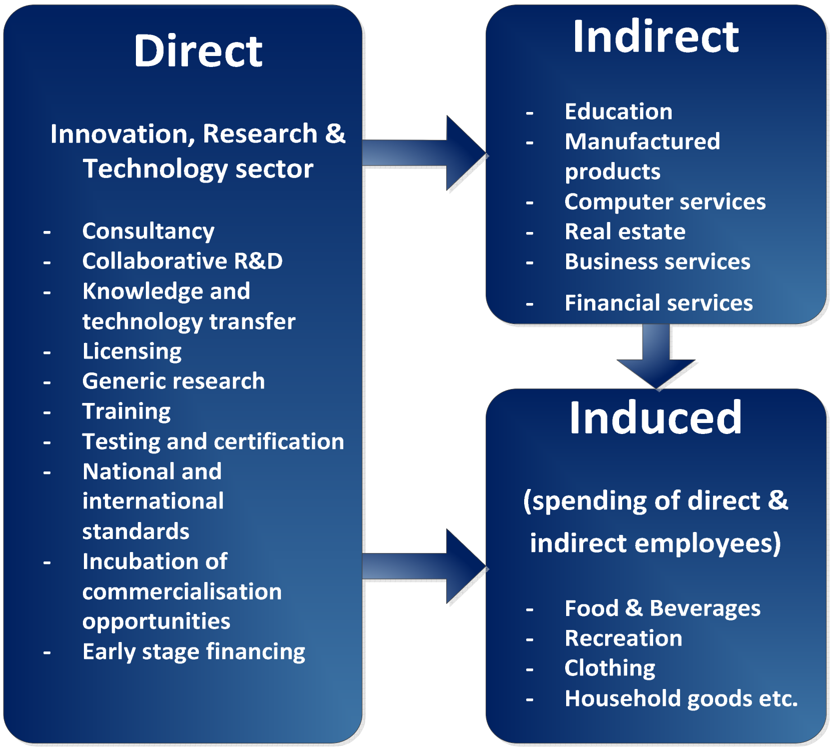
[12] For the purposes of this report, the activity of universities counted within the sector is limited to the commercialised component of their innovation activities (patents, university-owned spin-off businesses, graduate and staff start-ups, etc). For all other organisations, the starting point is total turnover rather than turnover specifically related to a narrow definition of R&D activity.

[13] Estimates of the indirect and induced impacts of the IRT sector are founded on detailed UK 2010 Input-Output Analytical Tables, using a technique first developed in Academia – see Leontief, Wassily (1986), 'Input-Output Economics, Second Edition'. The method is described in greater detail elsewhere in this section of the report.

[14] Gross value added (GVA) is commonly used to measure the contribution to GDP for a company or industry. For the whole economy, GDP is equal to GVA plus taxes on products less subsidies on products (ONS).

[15] A headcount basis allows for comparability to ONS data.

Figure 5.1: The channels of economic impact



Assessing direct impacts

The direct economic impact of the IRT sector, including direct GVA, employment, and tax receipts, was primarily estimated from information provided by IRT sector companies themselves. That includes information gleaned from detailed financial statements and organisations' survey responses[16].

Where published or survey data was not available to estimate employment, one of two assumptions was used. First, employment was estimated by applying a turnover per employee ratio to estimated or actual turnover for the organisation. The ratio, at £126,000 per employee, was calculated in an analysis of all IRT organisations for which Oxford Economics collected annual accounts[17]. Second, where neither turnover data nor employment figures were available, employment was estimated to be a weighted average (mean) for employment in micro and small businesses in the UK (ONS 2012)[18] within three ONS industry classifications[19].

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[16] Oxford Economics conducted a detailed survey of 36 AIRTO members, asking about their activities, turnover, costs, employees, taxes collected and paid, R&D expenditure, and a range of other questions.

[17] Oxford Economics collected annual account covering 80% of the turnover of the 230 companies included in the innovation, research and technology sector. Analysis of these accounts indicated that, on average, the turnover per employee in the sector is £126,000.

[18] ONS, (2012), 'Business population estimates for the UK and regions 2012'. Micro and small businesses in the UK are defined as businesses with between 0 and 50 employees.

[19] 712: Technical testing and analysis; 721: Research and experimental development on natural sciences and engineering; and 722 Research and experimental development on social sciences and humanities. These ONS (2007) most closely correspond to the ONS (2003) categories used by AIRTO to select the 174 organisations outside of AIRTO's membership that participate in the Innovation, Research and Technology sector. The weighted average number of employees in these sectors and for micro and small businesses is 13.

Where published or survey data was unavailable for turnover, one of two estimation methods was used. The first pertains to universities' innovation-derived income. Oxford Economics estimated this on the basis of intellectual property income earned by universities as well as the revenues earned by university spin-offs[20]. In 2012/13, this revenue totalled £1.4 billion[21]. This is 4.9% of total higher education income in the UK, at £29.1 billion[22]. Thus, to obtain an estimate of innovation-derived income for higher education institutions in AIRTO's membership – including City University London, the University of Greenwich, the University of Surrey and the University of Warwick[23] – each university's total revenue was multiplied by 4.9%.

Finally, where turnover was both unavailable and could not be estimated by other means, Oxford Economics estimated turnover by applying a ratio of £126,000 in turnover per employee[24].

Direct taxes collected and paid by the IRT sector were estimated from survey responses, published data on employment and employee compensation, and HMRC tax bands for PAYE, employer national insurance contributions (NICs), and employee NICs[25].

Estimating indirect and induced impacts using input-output modelling

Estimates of the indirect and induced impacts of the IRT sector are founded on detailed UK 2010 Input-Output Analytical Tables[26]. Produced by the Office for National Statistics, Input-Output Analytical Tables record the flow of spending on intermediate goods and services throughout the UK economy for a single year.

Oxford Economics Input-Output modelling takes advantage of this detailed accounting of intermediate flows. The models begin by quantifying the per-unit internal needs and external production capabilities of industries in the UK economy via Leontief inverse matrices[27]. That information is then coupled with estimated spend on inputs undertaken by IRT firms and spend on goods and services by their employees. The result is estimates of the total economic activity (i.e. output) associated with the IRT sector.

Estimates of gross value added are obtained by multiplying output in each affected industry by industry-specific GVA/Output ratios[28]. Estimates of employment are then estimated by dividing gross value added in each industry by productivity per employee – the gross value added contribution of each employee in a single year – in each industry[29]. Finally, taxes collected and paid as a result of indirect and induced economic activity are estimated using employment and

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[20] This includes spin-offs with some HEI ownership, staff start-ups, and graduate start-ups. It excludes formal spin-offs that are not HEI-owned.

[21] HESA, (2014), 'HESA Higher education-business and community interaction survey Part B tables'.

[22] Higher Education Statistics Agency (HESA), (2014), 'Income and expenditure by HE institution 2012/13 and 2011/12'.

[23] The University of Warwick's total income was used to estimate the turnover of the Warwick Manufacturing Group (WMG).

[24] Oxford Economics collected annual accounts covering 80% of the turnover of the 230 companies included in the innovation, research and technology sector. Analysis of these accounts indicated that, on average, the turnover per employee in the Sector is £126,000.

[25] HMRC (2013/14).

[26] ONS, (2014), 'Input-Output Analytical Tables'.

[27] Leontief, Wassily, (1986), 'Input-Output Economics, Second Edition'.

[28] Industry specific GVA/Output ratios are calculated using ONS, (2014), 'Input-Output Analytical Tables'.

[29] ONS, (2014), 'Annual Business Survey - 2012 Revised Results'.

turnover in conjunction with HMRC tax bands[30] as well as industry-specific gross operating surplus to turnover ratios[31].

Impacts reported on a gross basis

The core economic impacts in this report are presented on a gross rather than a net basis. The difference is whether account is taken of what the resources used up in the operation of the firm could alternatively be deployed to do. So, a gross study ignores alternative uses, whilst a net study estimates the impact created by the firm in excess of that if the resources were deployed in their second most effective use. The net approach is more complex and likely to involve greater controversy as the counterfactual (where the intervention does not go ahead) does not occur. It is therefore likely that views will differ as to what would occur in the firm's absence. Undertaking this study on a gross basis follows the dominant approach in the literature.

5.2 Wider impacts in the UK

Sections 6.2-6.4 and Chapter 7 cover a range of further impacts of the IRT sector on the UK economy and society – that is, impacts over and above the direct, indirect and induced, which for the IRT sector are of great significance.

These impacts include:

- Increased monetary returns for clients as a result of IRT organisations' consultancy, testing, R&D and other activities.
- Spillover benefits for third parties and the wider economy as a result of R&D aspects of the above work.
- Further private and spillover returns as a result of activities facilitating R&D by others, and activities enhancing the returns generated by others' R&D – including through collaboration, networking and facilitating business 'clustering'.
- Benefits from activities encouraging multinational investment projects to locate in the UK rather than elsewhere.
- Spillovers arising from the sector's role in enhancing the national skills base.
- Contributions to the achievement of environmental and other public wellbeing goals.

Of these, the last is essentially a non-monetary contribution to society that cannot be included in the overall monetary contribution to gross value even in principle, although this should not be seen as diminishing the importance of this work which is illustrated in some of the case studies included in the report.

Of the remaining channels of catalytic impact, robust quantification is only possible for one of the channels, namely the gains for clients and third parties as a result of IRT organisations' own R&D project work. These are estimated by combining the estimated turnover of the sector with the share of R&D project work in that total (as shown by a question in the survey), and applying a standard calculation of the associated returns based on findings across a range of academic studies. But as the actual returns on this R&D work are likely to be higher – they vary by sector

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[30] HMRC (2013/14).

[31] ONS, (2014), 'Input-Output Analytical Tables'.

and IRT organisations tend to operate in sectors with above-average returns – then even this will be an underestimate.

Consequently, the robust quantification misses out:

- The additional returns associated with IRT organisations' own R&D work due to the sectors in which this work takes place.
- Returns generated for clients by IRT organisations' non-R&D work.
- Returns associated with the three remaining channels of impact, i.e., R&D work undertaken by other bodies, multinationals' investment in the UK and enhancements to the UK skills base.

The case studies included in this report also include a number covering these channels, to illustrate how the benefits generated in these areas can be significant relative to the direct GVA of the organisations concerned. But in terms of quantifying the benefit, only a broad range of values is given for the combined total, this being the residual between an estimated range for the total gains possibly generated by the sector and the quantified direct, indirect, induced, client R&D and spillover R&D values.

The estimated range of values for the sector's overall value is based on the calculation of minimum and maximum values, with these in turn reliant on research-based findings concerned with the total GVA generated by each £1 of public spending in the science and innovation field. But this estimated range should be seen as illustrative and tentative.

6 The size and economic contribution of the IRT sector

Main points:

- In 2012/13, through its direct, indirect, and supply chain impacts, the IRT sector supported £7.6 billion in gross value added contributions to UK GDP. The sector has a gross value added multiplier of 2.08, so for every £1 million in economic activity it generates, it creates another £1.08 million in its supply chain and through wage consumption impacts.
- The IRT sector directly employed an estimated 57,200 people in 2012/13. That is similar to total academic staff at the Russell Group of UK universities.
- Across its direct, indirect, and induced channels, the IRT sector supported 140,100 people in employment in 2012/13. The sector had an employment multiplier of 2.4, so for every 100 people employed within the sector, another 140 are employed elsewhere in the economy.
- The IRT Sector is estimated to support a £2.9 billion contribution to tax receipts in 2012/13. This would have been sufficient to fund the wages of 41,000 doctors, 89,000 teachers, or 111,000 nurses.
- In addition to these standard economic contribution metrics, IRT organisations generate significant commercial benefits for clients, and 'spillover' benefits for the wider economy.
- If the recent level of IRT organisations' own R&D activity were maintained, then on the basis of standard assumptions the private return to clients would build to £3.5 billion per annum, and the spillover return to £6.3 billion per year. In practice, the benefits could be higher still due to the characteristics of the sectors in which IRT organisations operate.
- Further private and spillover returns are generated by IRT organisations' involvement in networking and their provision of facilities for business 'clustering' – encouraging others to undertake R&D and enabling and enhancing the private and spillover returns from others' R&D.
- The sector also helps to make the UK an attractive location for international business investment, through productivity-enhancing innovative projects and through contributions in the public policy arena such as involvement in Local Enterprise Partnerships.
- AIRTO members, making up 80% of the IRT Sector by turnover, directly generated £3.1 billion in gross value added for the UK economy. Furthermore, AIRTO members directly employed 47,000 people and paid an estimated £1.1 billion in tax.
- AIRTO members' gross value added per employee – commonly referred to as 'productivity' – was £65,400. As such, AIRTO members lead the sector in productivity and help to boost measured productivity in the country overall.
- AIRTO's membership is now similar to the well-known Fraunhofer network in Germany in terms of number of organisations, although AIRTO encompasses a wider range of organisation types and activities. AIRTO members produced 3.7 times as much turnover and employed 2.1 times as many people in recent years.

6.1 The ‘standard’ economic impact of the IRT sector

Oxford Economics’ analysis of the economic impact of the innovation, research and technology (IRT) sector in 2006[32] found the sector to be an important source of both jobs and gross domestic product (GDP)[33] for the UK economy. Since that analysis was conducted, the sector has seen some key firms grow in scale, while others contracted or ceased trading, and the UK economy entered and emerged from the most significant recession since the Second World War.

In light of these changes, this chapter updates and expands on the previous study to provide a detailed picture of the sector in 2012/13. This chapter measures the sector’s economic contribution using three metrics:

- **The gross value added (GVA)** contribution to the UK economy; [34]
- **Employment** measured on a headcount basis; [35]
- **Tax receipts** generated for the Exchequer.

Each of these metrics is evaluated across **three channels of impact** – **direct**, **indirect**, and **induced**[36] – which, taken together, comprise the ‘core’ economic contribution of the IRT sector on the UK economy in 2012/13.

For comparability, this study continues to use the definition of the IRT sector that was used in Oxford Economics’ analysis of the sector in the 2008 report (relating to the position in 2006):

- **AIRTO’s membership** – the 56 companies in membership as of June 2014, shown in Table 6.1. These organisations make up 80% of the IRT sector by turnover.
- Over **170 companies** selected by AIRTO from the following two ONS standard industrial classification (SIC 2003[37]) categories: **Technical testing and analysis** (SIC 74.3) and **Research and experimental development on natural sciences and engineering** (SIC 73.1).
- **Three catapults that are not already AIRTO members[38]**, namely Cell Therapy, Offshore Renewable Energy, and Future Cities.

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[32] Oxford Economics, (2008), ‘Study of the impact of the intermediate research and technology sector on the UK economy’.

[33] GDP is the most widely used measure of economic activity in the UK. It measures the market value of goods and services sold within the country, and is used to describe the rate of growth of an economy or when it enters or exits a recession.

[34] Gross value added (GVA) is commonly used to measure the contribution to GDP for a company or industry. For the whole economy, GDP is equal to GVA plus taxes on products less subsidies on products (ONS).

[35] A headcount basis allows for comparability to ONS data.

[36] A detailed description of these channels of impact is presented in the ‘Objectives, conduct and methodology’ section of this report.

[37] ONS, (2002), ‘Standard Industrial Classification of Economic Activities 2003’.

[38] The other four Catapults are AIRTO members, namely Connected Digital Economy Catapult, High Value Manufacturing Catapult, Satellite Applications Catapult, and Transport Systems Catapult.

Table 6.1: AIRTO's membership in this report's analysis

AIRTO members in the analysis[1]	
AFRC	Leatherhead Food Research
AHVLA	LGC
AMRC with Boeing	Lucideon Limited
ARUP	Medilink (Yorkshire & Humber) Ltd
AWE	MIRA Ltd
Axillium Research	MTC
BCIS	National Institute of Agricultural Botany
BHR Group	National Nuclear Laboratory
BM TRADA	National Physical Laboratory
BMT Group Ltd	NCC
BRE Group	NNFCC
BSRIA Ltd	Nuclear AMRC
Campden BRI	PA Consulting Group
CIRIA	Pera Technology
City University London	QinetiQ
Connected Digital Economy Catapult	Quotec Ltd
CPI	Satellite Applications Catapult
C-Tech Innovation	SATRA Technology Centre
Fera	SCI
FIRA International Ltd	Smith Institute
Fraunhofer UK Research Ltd	Thames Innovation Centre
Fripp Design & Research Ltd	Thatcham
Halcrow Group Ltd	The Scotch Whisky Research Institute
Health & Safety Laboratory	Transport Systems Catapult
High Value Manufacturing Catapult	TWI Ltd
HR Wallingford Group Ltd	University of Greenwich
Institute for Sustainability	University of Surrey
ITRI Ltd	WMG

[1] AIRTO members as at June 2014 and therefore counted as such in the statistical analysis in this report. Since then AHVLA has changed its name to APHA (Animal & Plant Health Agency).

Size of the direct impacts in 2012/13 and comparison with 2006

Based on a detailed analysis of annual accounts and survey responses from firms in the sector, Oxford Economics estimates that the innovation, research and technology sector itself generated £6.9 billion in turnover in 2012/13. From its turnover, the IRT Sector generated an estimated £3.7 billion in gross value added contributions to UK GDP (Chart 6.1). This is calculated as the turnover generated by IRT Sector organisations less their expenditures on inputs of goods and services used to produce their outputs[39].

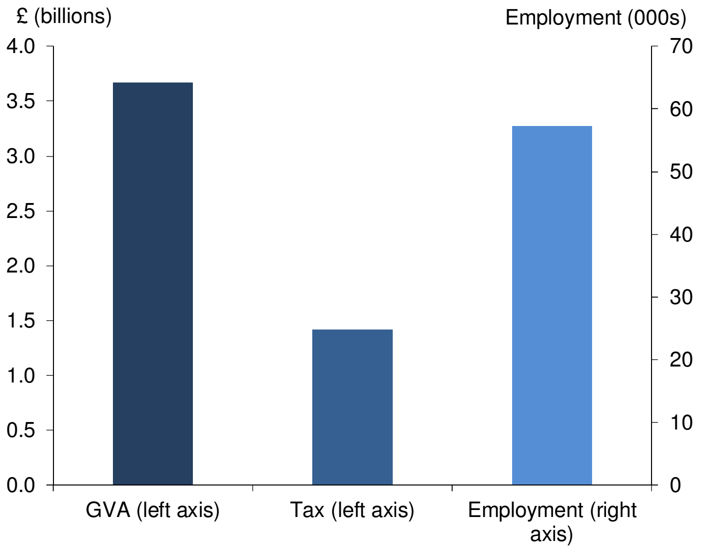
[39] This is the 'production approach' to calculating GVA, which is the value of the output produced less the cost of the non-wage inputs used to produce that output.

The sector's 2012/13 GVA contribution is three times as large as estimated for 2006. This increase is due in part to growth of members previously included in this analysis. But growth in AIRTO's membership base, which is used to define the sector, is an even more significant factor. Large, new joiners since 2006 include ARUP (turnover of £1 billion in 2012/13), AWE (£1 billion), and Halcrow (£465 million). Still, this may be an underestimate of the total sector size. Organisations may exist elsewhere in the economy that conduct innovation, research and technology related work without being classified in SIC 74.3 or SIC 73.1 categories and without being AIRTO members.

Firms in the IRT Sector are also a significant source of UK employment. In 2012/13, the sector employed an estimated 57,200 people. That is nearly 2.6 times the direct employment estimated to have been in the IRT Sector in 2006 and roughly equivalent to the total number of academic staff working at the Russell Group of UK universities in 2012/13[40].

Furthermore, organisations in the IRT Sector paid £1.4 billion to the Exchequer in 2012/13. Those payments were comprised of corporate taxes, business rates, excise duties, income taxes, and national insurance contributions[41].

Chart 6.1: Direct IRT sector contribution to the UK economy in 2012/13



Source: Oxford Economics

Productivity of the innovation, research and technology sector

Measured productivity of the IRT sector grew by 18% in money terms, or around 3% in real (inflation adjusted) terms, between 2006 and 2012/13. For comparison, real productivity was essentially unchanged across the economy as a whole during that time. Measured at £55,000 of gross value added created per employee in 2006, productivity in the IRT sector in 2012/13 is estimated to be £64,100 (Chart 6.2).

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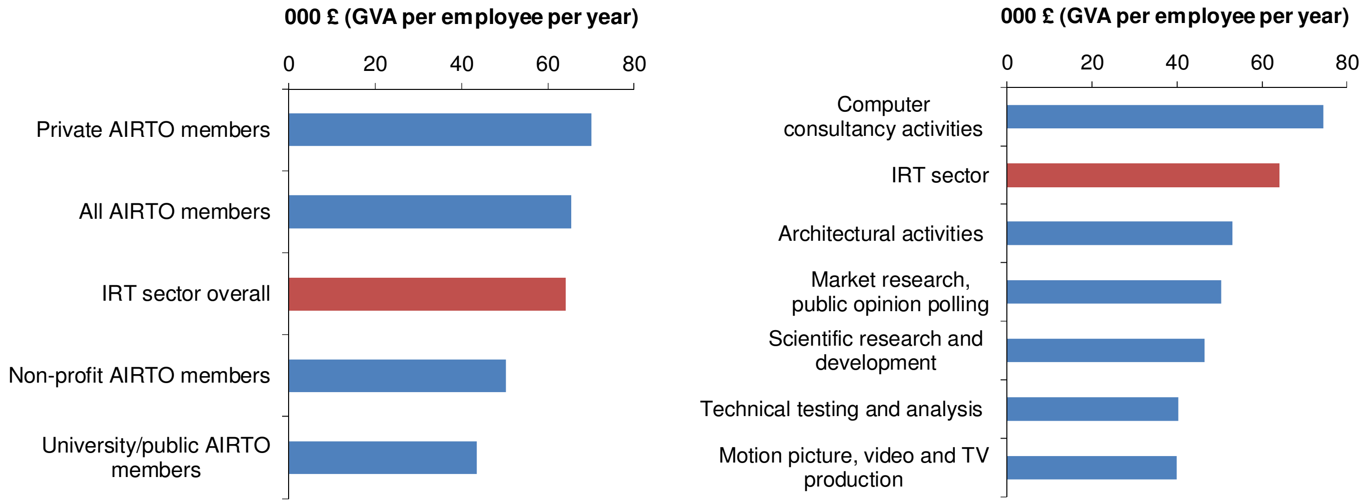
[40] HESA (2014), 'All staff by HE institution, academic employment marker and mode of employment 2012/13'.

[41] 2012/13 PAYE and NIC rates taken directly from HMRC website as of June (2014). Corporate taxes, net VAT payment, business rates and other tax payments (e.g., Vehicle Excise Duties, Congestion Charge, Climate Change Levy etc.) estimated using the midpoint of survey responses (i.e. a response of £50-200k was included in the corporate tax calculations as £125,000), scaled by turnover for those who did not fill out the survey.

As a result sector productivity is significantly higher than for the UK as a whole, which was about £44,200 in 2013[42]. IRT sector productivity is also higher than in the architectural services sector (£53,000), market research and public opinion polling sector (£50,400), the scientific research and development sector as a whole (£46,500), and the technical testing and analysis sector as a whole (£40,300). It is slightly lower than for the computer consulting sector (£74,400).

Chart 6.2: Productivity of the IRT sector and select UK sectors in 2012/13



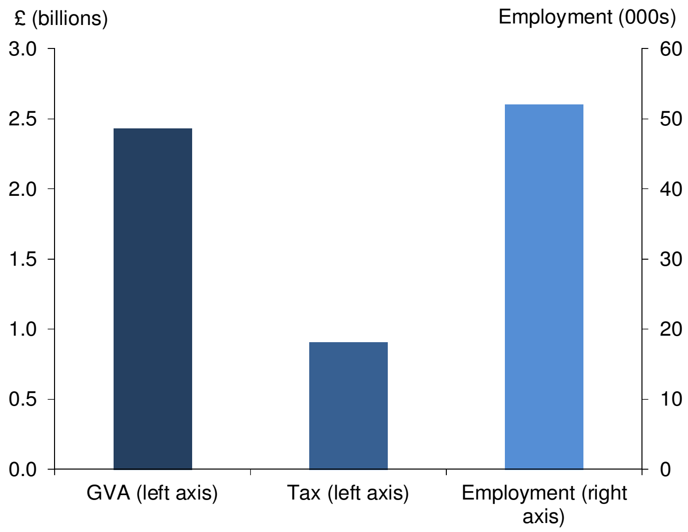
Source: Oxford Economics, AIRTO, organisations' annual accounts

Source: ONS, Oxford Economics

Indirect impacts

In order to produce outputs, the IRT sector purchases inputs of goods and services from other sectors. In 2012/13, that expenditure is estimated to be worth nearly £3.2 billion. This stimulates activity in still other sectors, as firms receiving the expenditure go on to make purchases in their supply chains. Using detailed impact models of the UK economy, Oxford Economics estimates that these effects – often referred to as 'indirect impacts' or 'supply chain impacts' – supported a £2.4 billion gross value added contribution to UK GDP in 2012/13 (Chart 6.3).

Chart 6.3: Indirect IRT sector contribution to the UK economy in 2012/13



Source: Oxford Economics

[42] ONS (2014).

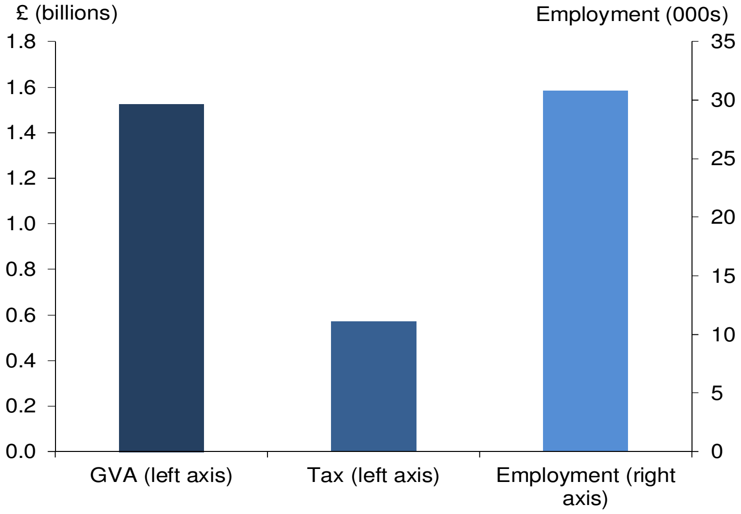
To produce this amount of economic output, firms in the IRT sector's UK supply chain employ significant numbers of people. Based on the indirect gross value added contribution, and employee productivity in the sectors which received the expenditure, 52,100 jobs are estimated to have been supported in 2012/13.

Recipients earn profits and pay taxes on those profits, and so do employees working in the supply chain. Together, an estimated £900 million in tax payments to the Exchequer were supported via IRT sector supply chain expenditures.

Induced impacts

The wage-financed consumption of IRT sector employees (as well as employees in the IRT Sector's supply chain) totalled an estimated £2.9 billion in 2012/13. These people spend a proportion of this income at retail outlets, restaurants, and on a range of personal services. Using Oxford Economics' detailed econometric model of the UK economy, this wage-financed consumption is estimated to support a further £1.5 billion in gross value added for the UK economy (Chart 6.4). At the same time, it supported an additional 30,800 jobs and £570 million in tax contributions to the Exchequer.

Chart 6.4: Induced IRT sector contribution to the UK economy in 2012/13



Source: Oxford Economics

Total impacts of wider IRT sector on the UK economy

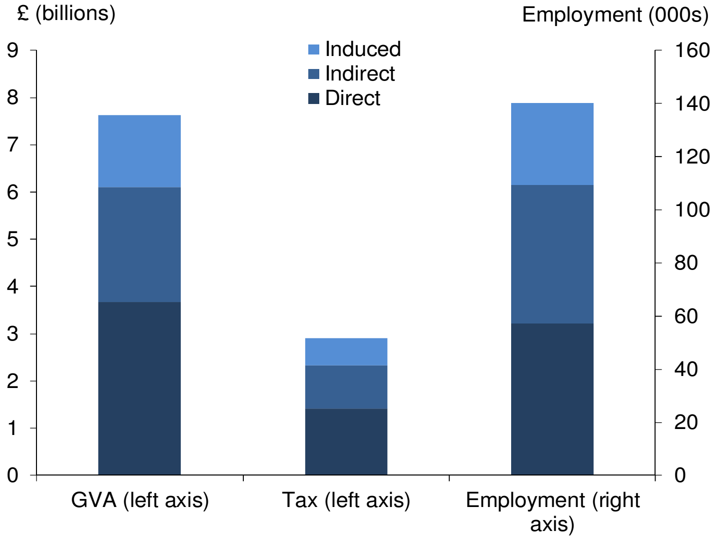
Aggregating across the direct, indirect, and induced effects, the IRT sector is estimated to support a total gross value added contribution to UK GDP of £7.6 billion (Chart 6.5). The sector therefore supports £1 in every £212 of economic output produced in the UK.

The IRT Sector's gross value added multiplier is estimated to be 2.08. So for every £1 million in economic output it produces, its supports £1.08 million around the rest of the UK economy.

In 2012/13, the IRT sector supported 140,100 people in employment. So 1 in every 212 jobs in the UK was partly dependent on the sector.

The IRT sector in the UK has an employment multiplier of 2.4. That means that for every 1,000 jobs created by the IRT sector, another 1,400 are supported through supply chain and consumer spending channels. The employment multiplier is slightly larger than the GVA multiplier because of the relatively high productivity of the IRT Sector.

Chart 6.5: Total IRT sector contribution to the UK economy in 2012/13

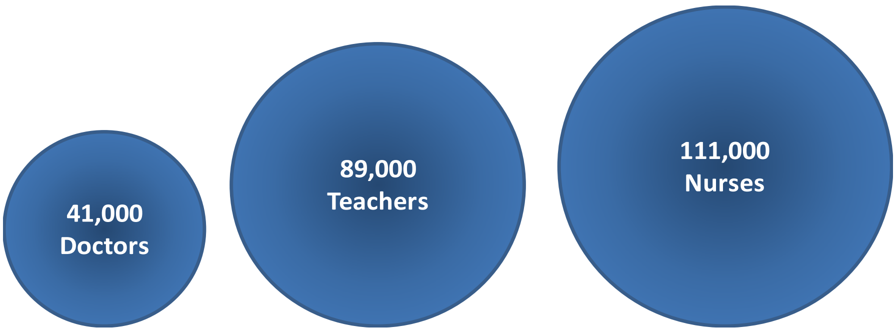


Source: Oxford Economics

Finally, the IRT sector supported a total of £2.9 billion in tax revenues in 2012/13 through the direct, indirect and induced channels. That is £44 per man, woman, and child in the UK. It would also be sufficient to pay for the wages of 41,000 doctors, 89,000 teachers, or 111,000 nurses[43] (Figure 6.1).

Figure 6.1: Tax receipts supported by the IRT sector

Number of doctors, teachers or nurses whose wages are covered by the tax contributions supported by the innovation, research and technology Sector

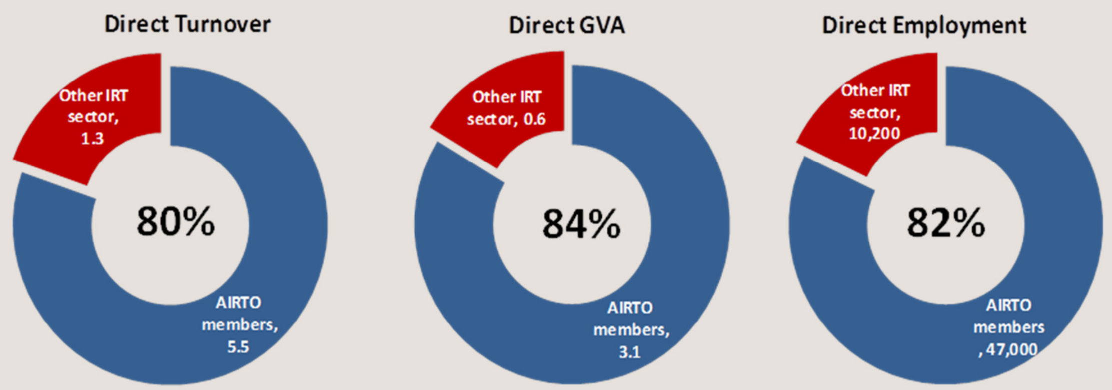


Source: Oxford Economics, ONS (2014)

[43] According to ONS, (2014), 'Annual Survey of Hours and Earnings'.

Box 6.1: The core economic impact of AIRTO members on the UK economy

The preceding analysis found that the **IRT sector** directly generated £6.9 billion in turnover and £3.7 billion in GVA, and employed 57,200 employees in 2012/13. The following three charts show that the **AIRTO members** – a large subset of the IRT sector as defined for the purposes of this study – **are key contributors** to this impact.



AIRTO members had an estimated turnover of £5.5 billion in 2012/13, meaning that they account for 80% of the IRT sector. From that turnover, AIRTO members themselves generated £3.1 billion in gross value added for the UK economy (84% of the IRT sector's direct impact) and employed nearly 47,000 people (82% of the IRT Sector's direct employment).

Industry leading productivity of AIRTO members

AIRTO members' gross value added per employee – commonly referred to as 'productivity' – was £65,400. That is nearly 50% higher than average productivity among all sectors in the UK in 2013. As such, AIRTO members lead the sector in productivity and help to boost measured productivity in the country overall.

Larger than the Fraunhofer network

AIRTO's turnover of £5.5 billion means that, collectively, its members are 3.7 times larger than the well-known Fraunhofer network in Germany, although AIRTO members encompass a wider range of organisation types and activities and employ 2.1 times as many people[44].

[44] Fraunhofer, (2013), 'Fraunhofer Annual Report: Research for greater efficiency'.

6.2 Commercial benefits for clients and associated R&D spillovers

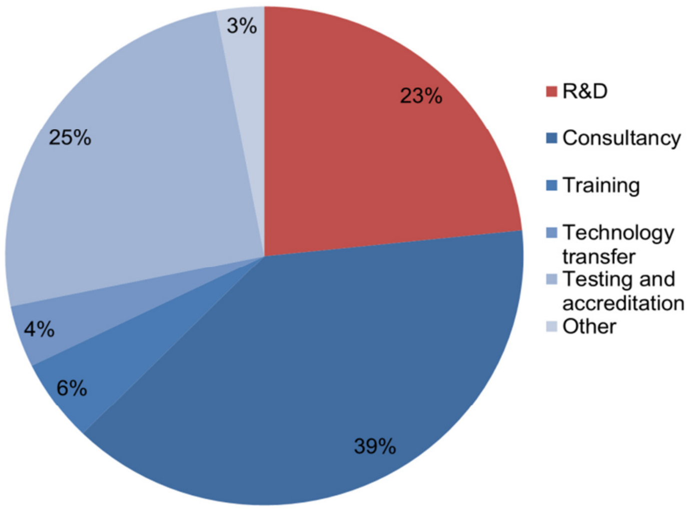
The 'core' contribution to the economy set out above – via the direct, indirect and induced channels – could in principle be calculated for any sector of the economy. But unlike many other sectors, the IRT Sector can be said to generate significant additional benefits for the wider economy, over and above those standard amounts, because of the nature of the organisations' activities.

Assessing these impacts requires detailed information about IRT sector firms, most of which is not public. As such, the following analysis draws heavily on Oxford Economics' survey of AIRTO members to make inferences about the IRT sector as a whole.

The IRT sector's activities and clients

Chart 6.6 shows how the sector's revenues break down by type of activity, based on the survey of AIRTO members. It can be seen how the vast bulk of turnover derives from consultancy work (39%), testing and accreditation activities (25%) and research and development (23%).

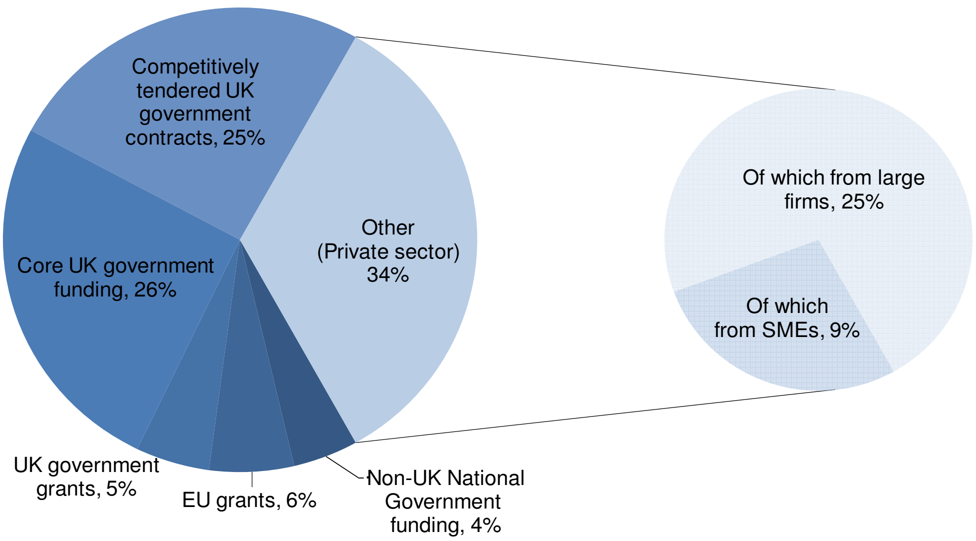
Chart 6.6: Survey respondents' revenue by type of work



Source: Survey of AIRTO members 2014
(Survey sample size: 35)

The largest source of turnover is private sector operations, which account for 34% of the total as reported by the 36 survey respondents (Chart 6.7). Within that, 25 percentage points (i.e. around three quarters) is generated by sales to large firms, and nine points by sales to small and medium sized enterprises (SMEs). The second largest source of revenue is core UK government funding (26%), closely followed by competitively-tendered UK government contracts (25%). EU grants, UK government grants, and non-UK national government funding provide 6%, 5%, and 4% respectively.

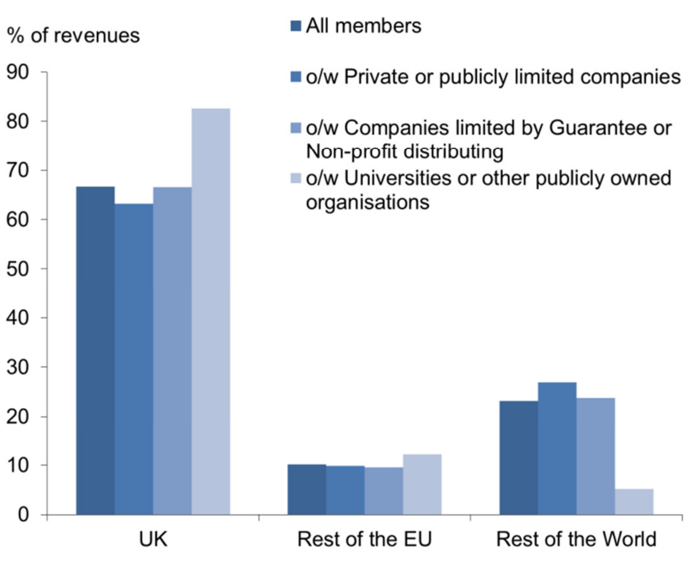
Chart 6.7: AIRTO members' revenue by source



Source: survey of AIRTO members 2014

The survey suggests AIRTO members receive 67% of their revenue from customers or funders in the UK (Chart 6.8), with the EU (at 10%) and rest of the world (at 23%) providing the remainder. Universities or other publically owned organisations are more dependent on UK sources for their revenue (at 83% of their total) compared to companies limited by guarantee or non-profit distributing (at 67%) or private or publicly limited companies (63%).

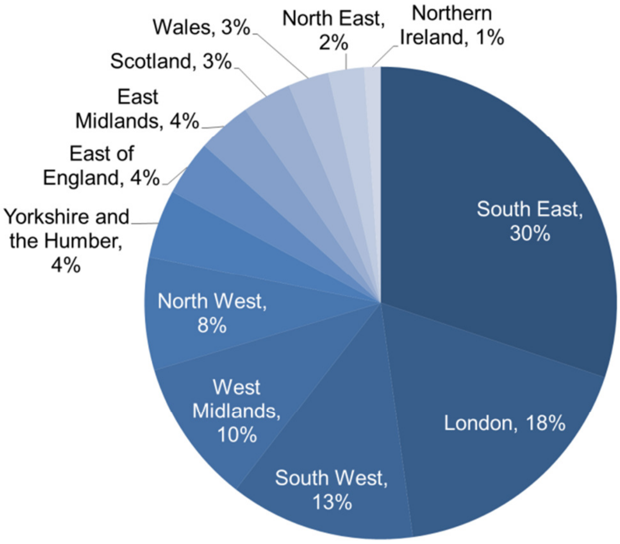
Chart 6.8: AIRTO members' revenue by location



Source: Survey of AIRTO members 2014

AIRTO members employ people in each of the UK's twelve nations and regions (Chart 6.9). Just under half (48%) are located in London or the South East. Thirteen per cent are located in the South West, 10% in the West Midlands and 8% in the North West. Yorkshire and the Humber, the East of England, the East Midlands, Scotland, Wales, the North East, and Northern Ireland account for a combined 21%.

Chart 6.9: AIRTO member's employment by region in 2012/13



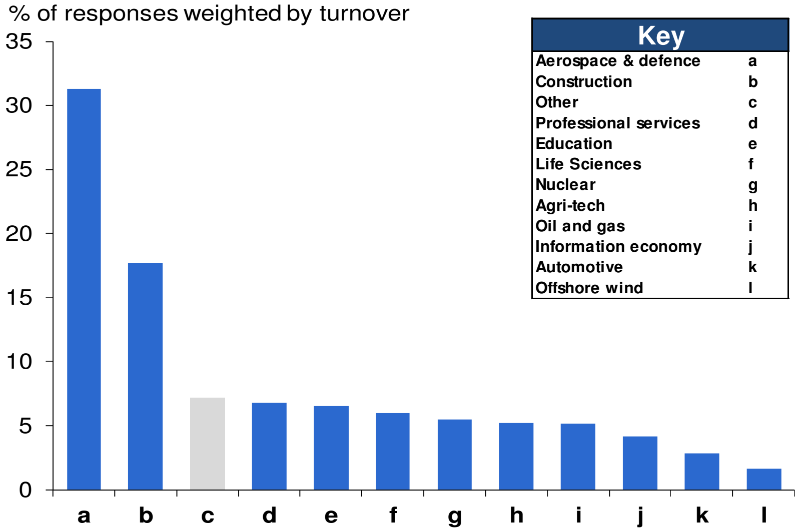
Source: Survey of AIRTO members 2014

Chart 6.10 meanwhile shows how revenues are split by field of activity (typically the industrial sector of clients or partners). It is weighted by turnover, to it reflects the revenues of all survey respondents in aggregate. Chart 6.11 also shows how revenues are split by field of activity, but in this case the responses are not weighted – i.e. the response of each organisation is counted equally regardless of size.

Apart from the 'other' category, the activities illustrated are 'BIS priority sectors', expected by the Government to make above-average contributions to UK growth going forward. These sectors comprise 'advanced manufacturing' (e.g., aerospace, automotive, life sciences), 'knowledge intensive traded services' (the information economy, some other professional services and traded aspects of further and higher education), and 'enabling sectors' (e.g., energy and construction)[45]. Less than a quarter of respondents' work by value takes place in sectors other than priority sectors, with AIRTO members having a presence in all of those key sectors.

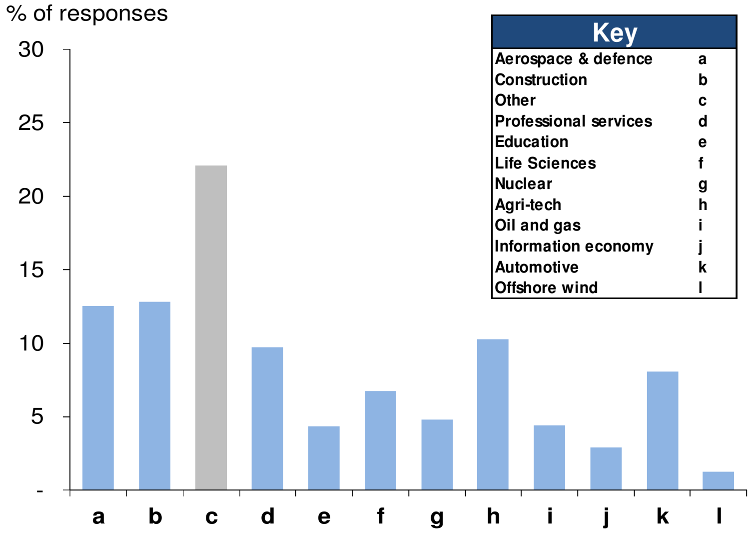
[45] See BIS Economics Paper No 18, *Industrial Strategy: UK Sector Analysis*, September 2012.

Chart 6.10: Survey respondents' revenue by sector of activity (weighted by turnover)



Source: Survey of AIRTO members 2014
(Survey sample size: 35)

Chart 6.11: Survey respondents' revenue by sector of activity (unweighted)



Source: Survey of AIRTO members 2014

(Survey sample size: 35)

Generating commercial returns for clients

The innovative nature of IRT organisations' consultancy, testing and R&D activities has the potential to generate very substantial commercial returns for clients. This is perhaps best illustrated through a case study (Box 6.2), concerned with the work of AIRTO member TWI on structural integrity.

Box 6.2: Case study on the enhancing the productiveness of fixed capital assets: TWI's work on structural integrity

TWI is a leading independent research and technology organisation with expertise in solving problems in all aspects of manufacturing, fabrication and whole-life integrity management technologies. Established in Cambridge in 1946 and with several facilities across the globe, the company has a long history of invention, innovation and knowledge transfer. It employs teams of internationally-respected consultants, scientists, engineers and support staff, whose knowledge and expertise are available to its industrial members as and when required.

Structural integrity – the reliability and safe design of engineered structures – is a key area of TWI's activity and the drilling rig life extension work carried out for Sedco Forex (now Transocean) provides a good example of this. In the early-to-mid 1990s, a number of that company's semi-submersible drilling rigs were reaching the end of their original fatigue design lives and in order to avoid the high capital cost of replacement, life extension of these rigs was investigated.

Life extension programmes were undertaken by TWI in relation to seven rigs over several years, at various locations worldwide including Rotterdam, Cape Town and Singapore. These involved analysis of the structures, inspection programmes, mechanical testing of materials from the rigs, on-site implementation of fatigue improvement techniques, and the calculation of fatigue life for the structures after repairs and modifications. The results of this work have allowed the drilling rigs to keep operating well past their original design life, saving the owners substantial amounts compared with the alternative of having new replacements built. Some of these rigs remain in operation today after re-assessment.

More specifically, Sedco Forex (SF) estimated that replacement of just one rig at that time would have cost in the region of $200 million. By contrast, the work carried out to double the structure's working life from 20 to 40 years cost just 10% of that amount per rig – including all necessary enhancements to ensure that robust international and UK standards, for safety and insurance purposes, continued to be met. On this basis the programme would have saved SF somewhere in the region of £1-1¼ billion at today's prices. While around 60% of the work was carried out by SF's own staff – and 40% by TWI staff – SF could not have developed the methods used without TWI's inputs.

Generating returns on R&D for clients and the wider economy

Oxford Economics' survey of AIRTO members suggests that R&D activity accounted for 23% of sector turnover in the latest financial year. As the industry's total turnover is estimated at £6.9 billion, this suggests that some £1.6 billion per annum of R&D is carried out by the sector – thereby accounting for around 6% of total economy-wide R&D activity in the UK[46]. A significant part of the potentially substantial commercial returns earned by clients, as a result of engaging with IRT organisations, will stem from these R&D activities.

But the economic benefits from research and development are not confined to such 'private' returns. The work can also lead to gains for other UK-based entities, and benefit the wider UK economy and society, through so-called 'positive spillover impacts'.

These spillover benefits can arise through channels such as the following:

- Sale of products embodying new technology and consequent take-up and imitation.
- Migration of staff from one firm to another, taking their knowledge with them.
- Shared access to intellectual capital, for example through collaborative research and/or university links.
- Partnerships between large firms and their suppliers aimed at improving the suppliers' products and processes.
- Other transfers of know-how through interlocking supply chains and knowledge sharing.

Academic studies have sought to quantify the economic benefits of R&D, with the private return to this activity[47] found to be very broadly 25% on average in the literature, but the total return found to be in order of 70%. The average spillover return – the difference between the two – can therefore be put in the region of 45% per annum[48].

On the basis of standard assumptions[49] used by Oxford Economics based on this academic work, if the sector maintained its recent volume of R&D activity on an indefinite basis the total benefit to the economy would eventually settle at around £9.8 billion per annum (measured at today's prices). Of this amount, the sector's direct clients could be expected to capture £3.5 billion per annum as a result of improved commercial returns, but there would be a larger spillover benefit to the wider economy in addition to that, building to £6.3 billion per year.

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[46] Put at £27.0 billion in 2012, according to the National Statistics 'UK gross domestic expenditure on research and development' release of March 2014. Overall, business was responsible for 63.3%, higher education 26.7%, government and research councils 8.0%, and private non-profit organisations 1.9%.

[47] The return to R&D is calculated in relation to the 'stock' of R&D – that is, the cumulative amount of R&D spending over many years with some allowance for 'depreciation'.

[48] See the Appendix Table 10.1 for more detail. Although the studies set out in that table date back to the 1990s and earlier, the results are still accepted as being applicable today. For example, the March 2014 ICF GHK paper for BIS, *An economic analysis of spillovers from programmes of technological innovation support*, states (page 10) that: "the literature does provide some indication of scale with net rates of private return on R&D investment typically estimated in the region of 20-30% to the primary beneficiary and net social returns from spillovers (i.e., those incurred by secondary beneficiaries) of 20-100 % of R&D investment, with an average close to 50% return".

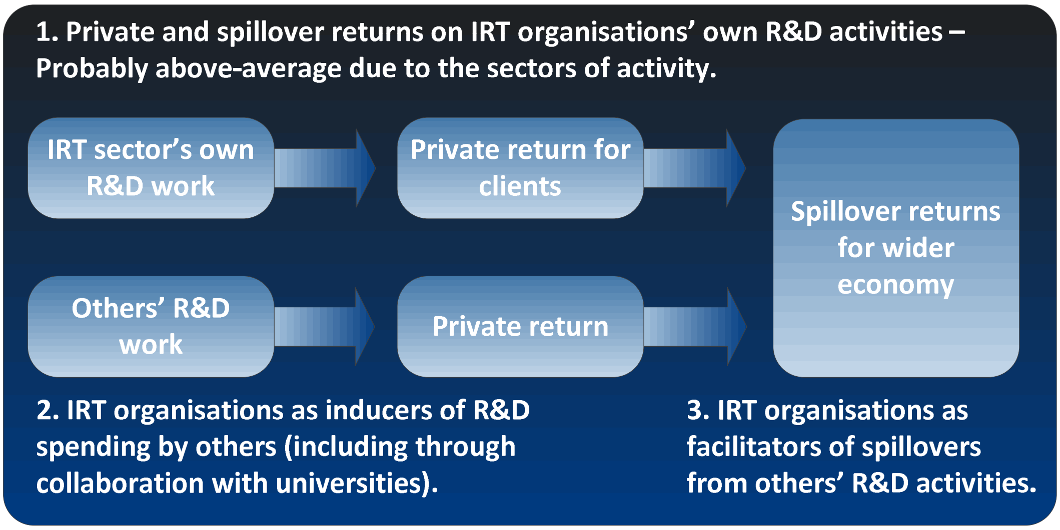
[49] A total return of 70% per annum on the R&D 'stock', split in a 25:45 ratio between private and spillover benefits, with the 'stock' depreciating at 10% per annum and no benefit felt after 20 years.

In practice, the benefits to both clients and the wider economy are probably even higher than suggested by this 'standard' estimation – which is based on average R&D returns across all relevant fields of activity – due to the sectors in which the work is carried out. Work previously undertaken by Oxford Economics (Appendix Figure 10.1) is consistent with total returns to R&D being higher than average in sectors of this kind, with for example aerospace and automotive amongst the highest-ranked of the industries able to be included in that study.

6.3 Generating benefits from others' R&D activities

In addition to the private and spillover returns generated by IRT organisations' own project work, these organisations also facilitate R&D work undertaken by other entities (Figure 6.2). And perhaps more importantly still, they undertake activities allowing research carried out by others to generate significantly greater private and spillover returns than otherwise.

Figure 6.2: IRT organisations' roles in securing and enhancing returns on R&D



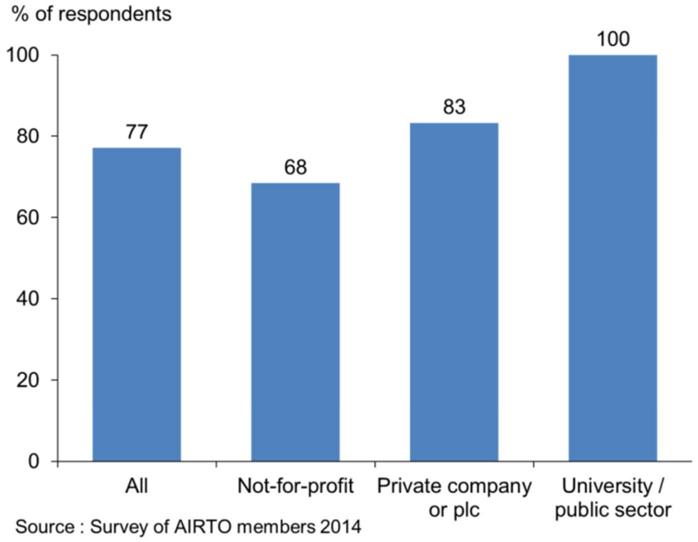
In particular, their activities can add significantly to the economic benefits of basic university research. Collaborative projects with universities, networking and knowledge-sharing more broadly with academia, government and industry, and facilitating collaboration between other businesses are all ways in which IRT organisations can be said to help to deliver benefits from others' research.

Collaboration with universities

Chart 6.12 shows how the majority of IRT organisations of all types – 29 out of 35 responding to this question, or 77% – undertake collaborative R&D projects with universities. This included all of the universities and other public sector bodies in the sample, while the proportion of private companies engaging in this activity (83%) was greater than that for the not-for-profit entities (67%).

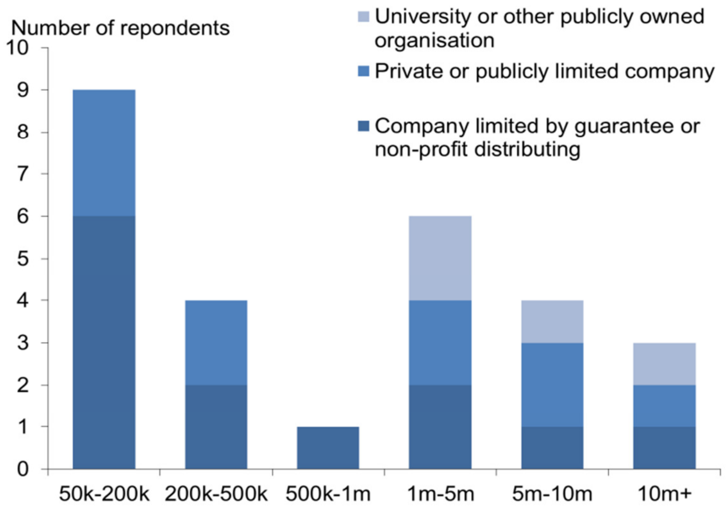
The results to a question on the value of these projects (Chart 6.13) suggest that over £80 million worth of this activity is undertaken annually involving the survey respondents. Maintained at that level indefinitely, and on the basis of the same standard assumptions as set out above, this would generate a total economic return for the wider economy eventually settling at close to £500 million per year. Some of this will be included in the benefits from IRT organisations' own R&D activity reported already, but that relating to the universities' share will be additional.

Chart 6.12: Survey respondents collaborating with universities on R&D



Source : Survey of AIRTO members 2014
(Survey sample size: 35)

Chart 6.13: Value of IRT-university collaborative R&D projects



Source : Survey of AIRTO members 2014

(Survey sample size: 35)

Collaboration, networking and facilitating business 'clustering'

More generally, IRT organisations are well positioned to collaborate with academia, government bodies and businesses in order both to develop innovative products and processes – and solutions relating to commercial and public wellbeing issues – and to facilitate the private and spillover returns associated with that work.

Collaboration between IRT organisations and industrial businesses – and collaboration and networking between third party businesses facilitated by IRT organisations – can also secure and enhance the private and spillover returns to R&D, whether that R&D is carried out by the industrial companies, by the IRT organisations or jointly. Where this collaboration and networking takes place as a result of organisations being located close together physically, the R&D spillover returns can be thought of as part of the wider set of economic benefits delivered by so-called 'agglomeration' – benefits which include other gains from networking, economies of scale and (provided that the site is well-located) ready access to customers, labour and essential supplies.

It is difficult to quantify the overall benefit to the economy and society stemming from activities of these kinds, but Chapter 7 of this report – examining the wider benefits of the sector – includes several case studies of relevance.

Box 6.3: A previous study on the economic impact of the University of Surrey in 2012/13

Universities, which have a core mission for teaching and research, have been encouraged by Government to increase their knowledge transfer activities in recent years. Some of this activity involves applied research and technology translation which is geared towards mid-TRL activities with industry. The overall impact of the university sector in this regard is complimentary to that of the IRT Sector and is an important component of the UK's innovation infrastructure.

For example, the University of Surrey recently commissioned a study[50] to quantify the direct and indirect impacts of the University on the town of Guildford, the county of Surrey, and the UK.

The study reported that the University, in conjunction with its Research Park, "generated £1.4 billion for the UK economy" and "supported almost 16,200 jobs in 2012/13."[51]

The University can act as a catalyst for driving innovation in the local area, by bringing together key partners, exemplified by the formation of Surrey Satellite Technologies, a company originally formed and incubated from within the University of Surrey and now operating within the Airbus Defence and Space Group.

The study also identified a range of less quantifiable benefits of the University of Surrey, including the provision of sports and leisure centres at Surrey Sports Park, the social contribution of student volunteers and benefits to local children of University-led events and activities.

6.4 Making the UK an attractive location for globally-mobile businesses

IRT organisations play an important role in helping to make the UK an attractive place for multi-national investment, which is an important contributor to national economic production.

The importance of multi-nationals' investment to the economy

National output can be thought of as being essentially determined by five factors: the amount of productive fixed capital; the level of technology and innovation embodied in that capital and in associated production processes; numbers employed; the skills and knowledge of the workforce; and the way in which these resources are managed and utilised to get the most out of the capacity available.

Investment by multi-nationals can make an important positive contribution in all of these areas:

- Net foreign direct investment flowing into the UK in 2012 amounted to £35.4 billion, sufficient to fund 28% of all fixed investment in business assets in that year. Investment by British multinationals in the UK would have been additional to that, while UK companies' net direct investment overseas amounted to £26.5 billion.

[50] BiGGAR Economics, (2014).

[51] These figures are not a part of this report's stated impacts, as they include the impact of the entire University rather than just innovation related activities.

- Productivity associated with direct inward investment will often be higher than the existing national average, reflecting a combination of technology, skills and process organisation and driven by the greater level of exposure to world-leading technology and techniques. There is also a body of economic literature[52] supporting the view that such highly productive foreign direct investment can boost the productivity of domestic companies, both through competition impacts and through knowledge 'spillovers'.
- In the short term global demand for labour can be less than fully flexible so there is a sense in which locations are competing with each other for a set number of jobs on offer. Jobs directly supported by new inward investment, or by UK-owned multinationals choosing to locate a project at home rather than abroad, can therefore push national employment above the level that would otherwise prevail at least for a while. To the extent that high productivity associated with this investment results in lower unit costs, this will make exports and import-substitutes more competitive, reinforcing the UK's ability to sustain this higher share of global output and jobs and potentially making the nation a more attractive place to locate further projects – thus creating a 'virtuous circle'.
- In the longer term the net impact of such productivity-driven competitiveness achievements on job numbers can be more limited, as in their absence price, wage and exchange rate flexibility would tend (as far as allowed) to boost the number of jobs provided by domestic companies and absorb any 'spare' labour. However, in the latter scenario real wages would be lower, reflecting the impact of both lower productivity and exchange rate weakness (which will boost import prices). And higher investment will have a permanent net positive impact on numbers employed, as well as on wage levels, where higher pay is associated with increased labour supply, and/or where labour market inflexibilities (e.g. minimum wages) could prevent alternative jobs being created in the lower investment scenario.

Investment associated with IRT organisations' work on innovation

The most direct way in which IRT organisations help to secure UK-based investment by multinational companies is through their involvement in joint project work on product, equipment and process innovation.

'Catapults' are technology and innovation centres established by Innovate UK "where the very best of the UK's businesses, scientists and engineers can work side by side on research and development, transforming ideas into new products and services to generate economic growth"[53]. These include the High Value Manufacturing Catapult, one of whose research centres was instrumental in ensuring that a key Rolls-Royce investment was located in the UK rather than elsewhere (Box 6.4).

That project is a good example of an initiative specifically aimed at boosting productivity and efficiency and reducing unit costs, but as a result enhancing international competitiveness and securing well-paid UK-based employment. Without the facilitating role played by IRT

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[52] See for example Jonathan Haskel et al, *Does inward foreign direct investment boost the productivity of domestic firms?* NBER Working Paper 8724, January 2002.

[53] Catapult Programme website home page.

organisations such as HVM Catapult, both productivity-enhancing investment and the associated well-paid jobs could be lost to the UK economy altogether.

Box 6.4: Case study on the creation of new productive capacity in the UK: HVM Catapult, the Advanced Manufacturing Research Centre and Rolls-Royce

Catapult centres are fostered by the Technology Strategy Board to enable UK businesses, scientists and engineers to work together on research and development to transform ideas into new products and services. The High Value Manufacturing (HVM) Catapult, which aims to accelerate the commercialisation of new and emerging manufacturing technologies, is one of seven such organisations already up and running. HVM Catapult in turn comprises a network of seven entities, one of which is the Advanced Manufacturing Research Centre (AMRC).

Located in Rotherham and affiliated to Sheffield University, this research centre focuses on advanced machining and materials research for aerospace and other high-value manufacturing sectors. Its researchers work with individual companies on specific projects, and collaborate on generic UK & European funded projects

Rolls-Royce engineers worked closely with the staff at the Advanced Manufacturing Research Centre to develop manufacturing methods which are now being put into operation at the new Rolls-Royce factory at Radial Business Park in Washington, Tyne & Wear. This £100 million facility was officially opened in June 2014 and is the new location for the production of fan discs and turbine discs. These discs will feature in a wide-range of Trent aero engines including the world's most efficient aero engine the Rolls-Royce Trent XWB.

Given the physical stresses and high temperatures endured by these discs throughout their multi-year lifespan, intelligent design, high-performing materials, complex processes and an intense level of scrutiny are all required in the manufacture of these parts. The turbine disc is manufactured using advanced powder metallurgy, coupled with state-of-the-art forging and machining technologies, all of which must guarantee component temperature and strength capacity at the lowest possible weight.

These requirements could make for a costly process with limitations on the amount of product that could be manufactured each year. Yet thanks to the development work undertaken at the AMRC, the time taken to manufacture each disc has been reduced by 50% – alongside a step-change in manufacturing productivity. The introduction of robotics and automation, and use of the latest advanced process platforms, has been central to this achievement.

As a consequence, when the Washington facility is fully operational in 2016, it will have the capacity to manufacture 2,500 fan and turbine discs per year. The substantial efficiency savings made helped underpin the commitment of Rolls-Royce to locate production and build a new disc facility in the North East of England. This helped to safeguard many skilled jobs in the region.

Further examples of the Catapult Network's activities being associated with investment and job creation in the UK include:

- The Satellite Applications Catapult's aim to help the UK achieve the targets set out in the 2010 UK Space Innovation and Growth Strategy, namely to grow the UK's share of the world's space economy from 6.5% today to 10% by 2030. If UK Space Innovation and Growth Strategy targets were achieved, the UK-based space-enabled sector would have an annual turnover of £40 billion in 2030, with growth between now and then sufficient to generate an additional 100,000 jobs[54].

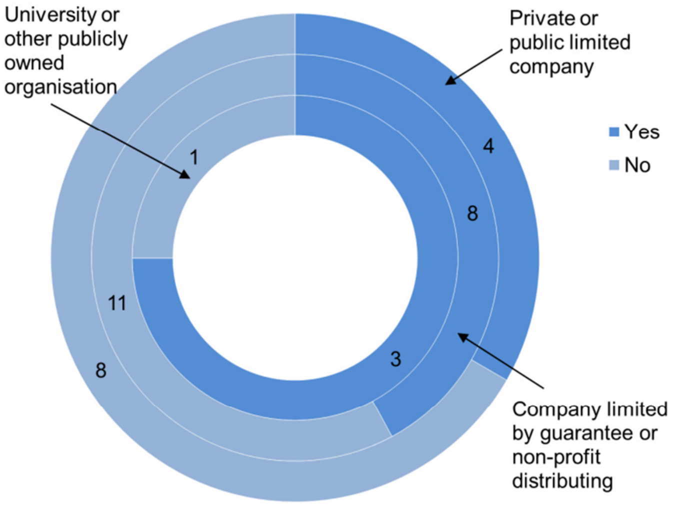
- Siemens' involvement in renewable energy production, having worked with the Offshore Renewable Energy (ORE) Catapult. This includes development of Skerries Array tidal energy farm off the Welsh coast by Siemens-owned Marine Current Turbines, which made use of the ORE Catapult's Nautilus testing facility and which is expected to be able to provide eco-friendly electricity for up to 100,000 homes after coming into operation in 2016.
- ORE Catapult could also welcome the March 2014 announcement by Siemens and Associated British Ports of investments in manufacturing facilities in and around Hull to produce offshore wind turbines. These projects will involve capital outlays of £310 million and are expected to create up to 1,000 jobs directly.

IRT organisations' contributions to the industrial growth policy framework

A further way in which IRT organisations help to make the UK an attractive place for businesses to locate is through their involvement in shaping public policy as it affects the landscape for economic and industrial growth.

This is perhaps best illustrated at the local level, where AIRTO members are involved in Local Enterprise Partnerships. Among other things, these partnerships between English local authorities and businesses help to determine priorities for investment in roads, buildings and facilities in the local area, thus contributing to the attractiveness of the area to other businesses. As Chart 6.14 illustrates, eight out of 19 not-for-profit IRT organisations are involved in LEPs, together with a further four limited companies and three public sector AIRTO members.

Chart 6.14: Survey respondents' involvement in Local Enterprise Partnerships



Source: Survey of AIRTO members 2014

(Survey sample size: 35 AIRTO members)

[54] Space IGS, *Space Growth Action Plan*, November 2013.

7 Wider benefits of the IRT sector

Main points:

- The sector enhances the UK's economic wellbeing, through its collaboration and networking activities and by facilitating collaboration between third party businesses (albeit in ways difficult to quantify). All of these activities help to promote innovation and to enable and enhance the private and spillover returns derived from that innovation.
- Real-life instances of collaborative projects include UK Knowledge Transfer Partnerships and EU Framework programmes for example, while real-life examples of facilitating collaboration between third party businesses include the running of technology parks.
- The sector also contributes to the development of the UK's skills and human capital base, through its employment of high-qualified workers, employment of students still in higher education, engagement with schools, and training offerings including apprenticeships.
- Real-life studies show how the sector also helps to advance society's wider policy goals, including in the environmental, health, and public safety sectors.

In this Chapter we examine the ways in which IRT organisations generate wider benefits, including economic benefits that cannot be easily quantified (other than through individual case studies at project level) and through contributions to environmental, social and other public wellbeing goals.

7.1 Collaboration and networking across the public and private sectors

Real-life examples of innovation driven by co-operation and knowledge-sharing across the public and private sectors include the industrial collaboration of MIRA Technology Park (Box 7.1), work of the Institute for Sustainability (Box 7.2), the KTP involving Leatherhead Food Research (Box 7.3), a collaborative project by the National Structural Integrity Research Centre (Box 7.4), a collaborative project on a medical device managed by Pera (Box 7.5) and a project by TWI (Box 7.6).

Box 7.1: Case study on fostering collaboration amongst industrial businesses: MIRA Technology Park

MIRA Ltd – formerly the government-funded Motor Industry Research Association but now an independent company – undertakes research, product engineering and test development in advanced engineering fields. It has grown significantly since its foundation in 1946 operating globally with offices and representation in 10 countries. The company operates within the transport sector with the main business areas being automotive, defence, aerospace and rail industries and includes the development of ground-breaking low carbon vehicle and intelligent mobility technologies. Its services range from component level design and testing through to turnkey system and whole vehicle design, development and build programmes, with capabilities in a wide range of vehicle-related engineering and technology fields and in related activities such as testing for product safety and certification.

The MIRA site has a very comprehensive range of facilities including over 35 major laboratory test facilities and the UK's most comprehensive 93km proving ground. The 600 strong MIRA team also has a global reputation for its engineering expertise

The MIRA Technology Park

The organisation is headquartered at the secure 842 acre MIRA Technology Park in Leicestershire (close to Nuneaton) where it also plays host to a number of leading global companies in the transport and related engineering sectors. Currently MIRA Technology Park is host to around 30 major companies including Bosch Engineering Group, Toyota, Continental, GKN, Goodyear Dunlop, Jaguar Land Rover, Triumph, Haldex, Lockheed Martin and many other well-known global brands

The Technology Park allows customers to have a bespoke R&D centre benefiting from proximity to MIRA's world-class facilities and engineering capabilities, combined with the associated benefits of being part of a recognised centre of excellence and a focused technology cluster in the heart of the UK's automotive industry. The project was also boosted in 2011 by the granting of Enterprise Zone status – expediting the development and bringing benefits to companies establishing themselves within the Zone.

MIRA Technology Park has planning consent to expand to 155,000m^2 of R&D floor space and is focused on attracting many more businesses looking to establish an R&D operation in the UK. It is anticipated that around 2,000 jobs will be created, the majority being high value technology posts. Around 320 positions have already been created and filled. Working together with FE and HE partners, funding has also recently been secured for the development of a national specialist skills centre based at MIRA Technology Park to address specific skills gaps in the transport R&D sector.

Box 7.2: Case study on networking with public and private entities: Institute for Sustainability

The Institute for Sustainability (IfS) is a charity set up in 2009 to support cross-sector collaboration and innovation. Its core aim is to accelerate the delivery of economically, environmentally and socially sustainable cities and communities by driving innovative demonstration projects and developing programmes to share best practice in the field. Alongside Imperial College London, the IfS acts as UK lead on several projects funded by the Climate Knowledge and Innovation Community (Climate-KIC), the European Union's main climate knowledge transfer and innovation initiative.

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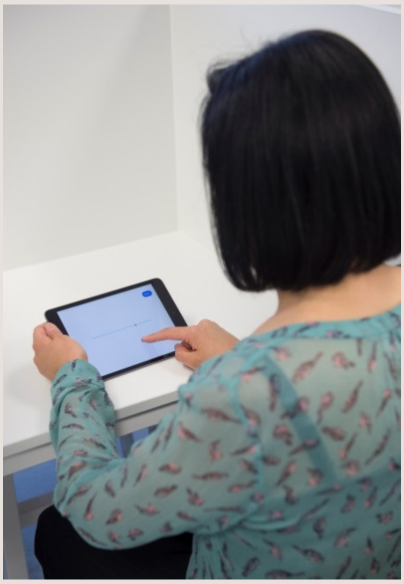
The Clean, Restore, Protect nanotechnology coating for photovoltaic systems

The Sustainable Innovation Forums form one such project. These aim to clarify and shape opportunities available to members – who are owners and managers of commercial buildings and potential buyers of climate innovation products and services – and to shorten time-to-market for new offerings in this area. Members define the real world challenges that they are facing and the IfS (helped by Climate-KIC expertise and resources) shapes activity to help address them – in turn prompting suppliers, innovators and researchers to respond with solutions. Recent initiatives include behaviour change pilots in multi-tenanted buildings and challenge-led competitions to find innovative photovoltaic (PV) and building metering and monitoring technologies

Box 7.3: Case study on Knowledge Transfer Partnership projects: Leatherhead Food Research

Leatherhead Food Research is an independent membership-based organisation delivering regulatory advice, scientific research and market and consumer insights for the worldwide food and drinks sector. Its consultants include experts in food law, science, market research and crisis management. The organisation has recently been involved in a Knowledge Transfer Partnership Project (KTP) concerned with testing the effects of food and drink products on cognitive performance.



The Leatherhead Food Research iPad

Robust clinical evidence of health benefits is required by the European Commission before a health claim can be displayed on product packaging. Market intelligence has shown that evidence of improved cognitive function, encompassing several domains (e.g. memory, attention, alertness, and problem-solving), is a very current industry need. In collaboration with the University of Sussex, this KTP aims to develop a knowledge base of cognitive tests and a software platform run on the latest hand-held technology, to support the food and beverage industry in product development and health claim substantiation.

Box 7.4: Case study on IRT organisation, Industry and University Collaboration: The National Structural Integrity Research Centre

The National Structural Integrity Research Centre (NSIRC) is a state-of-the-art post-graduate engineering facility established and managed by structural integrity specialist TWI, working in collaboration with a number of universities including lead academic partner Brunel University, and the universities of Cambridge and Manchester. Government funding is supporting the establishment of the Centre with a new building and the necessary equipment, and industrial support is being provided by a number of sponsors including BP and Lloyd's Register.

NSIRC was proposed by TWI, and its partners, following a government challenge to establish a new type of industry-led post-graduate university, and has received widespread support from key players in science, research and industry. It addresses two key requirements of the UK in order to support advanced manufacturing industries, new national infrastructure projects and an ageing asset base:

- A supply of suitably qualified engineers and scientists in the field of structural integrity.
- A foundation of academic research to provide new concepts and methodologies that will advance the application of structural integrity to the new challenges set by industry.

Structural integrity is the science of ensuring manufactured items and structures are fit for their designed or extended service life.

NSIRC will be housed in a purpose-built facility currently under construction on the TWI Cambridge campus – scheduled for completion at the beginning of 2015. PhD students are already in place and the first Masters course starts in October 2014. Numbers of post-graduate students will increase over the next few years with a target of 530 completing their course or research in the first ten years of operation.

Box 7.5: Case study on collaboration to achieve a health objective: Pera Technology and the 'Trem-End' project

Pera Technology provides new product development expertise to support the commercial success of UK and European businesses of all sizes and in all sectors. Its advice and support services cover the whole of the production cycle from conception to creation and commercialisation. Medical devices are just one of many product areas in which the company is involved but the Trem-End project provides a pertinent example of its work.

Over 4.25 million people throughout Europe suffer from involuntary arm tremors. As a result fine motor tasks such as eating and writing become very difficult for the patients and this drastically decreases quality of life. Yet current methods of overcoming this disabling condition are costly, ineffectual or disliked by patients.

The 'Trem-End'

Drawing on Seventh Framework Programme funding, a consortium of seven private and public sector organisations from across Europe came together and were project managed by Pera Technology. The aim of the Trem-End project was to develop an innovative and more cost-effective commercial medical appliance for tremor suppression at the wrist of patients resistant to conventional treatments. The device implements an innovative mechanism that not only reduces obtrusiveness, but also increases tremor suppression efficacy compared with current solutions. Validation trails were highly successful and as a result the Trem-End product is now commercially available.

Box 7.6: Case study on Technology Transfer: TWI

For the past 20 years, TWI has been formally involved in the management and delivery of technology transfer (TT) projects. Informal involvement, however, has been underway for roughly 60 years. TT requires understanding the technical requirements of a company – what is slowing their development, costing them excessively, causing them to lose business or be unsafe? The next step is to identify who has the knowledge and experience to make a difference and to deliver that support. The final stage is to understand the business effect on the company of the assistance provided – this is most often measured in terms of jobs and turnover created or safeguarded.

TT is provided – usually but not always to SMEs – in a logical but flexible sequence, starting with a scoping visit which results in a proposal for support, detailing the problem and how it will be tackled. Possible business impacts arising from this support are identified at this stage. This is followed by the main support provision which can be up to 1-2 weeks of activity, on-site and/or in TWI's workshops and test facilities.

In 1994, TWI won a major TT project funded by the DTI. This resulted in five years of nation-wide activity. Since the conclusion of that programme, TWI's TT projects have been funded mainly by the RDAs – often using ERDF funding – and recently by the Regional Growth Fund. Projects have been successfully delivered in Scotland, the North East, the North West, Yorkshire and Wales and have covered industry sectors as diverse as electronics and nuclear power. Each project is tasked with significant targets in terms of business impacts achieved: since 2004, TWI has kept records that show its Technology Transfer activity has boosted business performance in the UK regions by creating or safeguarding over 5,200 jobs and £330 million of turnover.

7.2 Developing essential skills and human capital

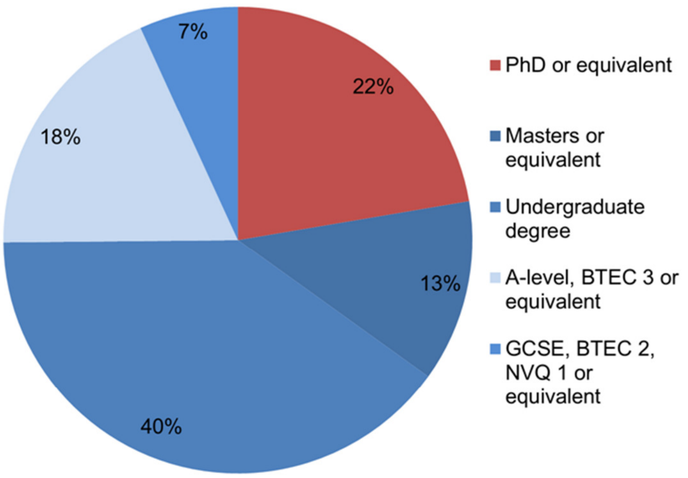
The sector contributes to the development of the nation's skills and human capital base in four ways: through its own employment of highly-skilled staff; through its employment of students still in higher education; through its engagement with students while they are still at school; and through its provision of training including apprenticeships. We look at these four channels in turn.

The sector's own employment of highly-skilled staff

Chart 7.1 shows how AIRTO members employ a well-qualified workforce. Based on the survey, 22% of all employees hold a PhD or equivalent, with 75% educated to at least degree level. For comparison, in 2013 some 28% of the relevant population of working age were classified as graduates by the Office for National Statistics[55].

[55] The base here comprises men aged 21-64 and women aged 21-59, excluding those enrolled on an educational course. Source: Office for National Statistics, *Graduates in the labour market 2013*. An individual is classified as a 'graduate' for these purposes if they have any qualification higher than an A-level.

Chart 7.1: Survey respondents' UK employment by staff qualification



Source: Survey of AIRTO members 2014

(Survey sample size: 36)

One consequence of IRT organisations' employment of highly-qualified staff is that typical wages in the industry are well above the national average. Based on the survey results, wages per head amongst AIRTO members averaged £47,800, while official data[56] put average earnings across the 'R&D in natural sciences & engineering' sector at around £45,400 (or £47,100 for full-time employees only). The national mean wage for comparison is some £27,200 (full-time: £33,300).

The sector's high employment of graduates is made all the more important by the wider situation facing more recent graduates today, with HESA data showing some 14% of those gaining a first degree in 2011-12 studying for a higher qualification six months later, and 6.7% recorded as unemployed and looking for work[57] – not that far below the overall unemployment rate of 7.8% at that time (late 2012 / early 2013). The ONS dataset meanwhile shows that while unemployment amongst graduates out of education for more than five years has edged down recently, to just 3% of the workforce, unemployment amongst more recent graduates has become stuck at close to 9% – compared with around 5% in 2007 ahead of the recession.

The heavy concentration of graduates in the public administration, health and education sectors is also worth noting, with some 41% of all working graduates (on the ONS definition) employed in those industries compared with 22% of all non-graduates. With public sector employment on a clear downward path and quite possibly set for a further squeeze in the years ahead, the provision of graduate-level jobs in commercial and not-for-profit operations – which the majority of IRT organisations are – has become all the more desirable.

[56] Office for National Statistics, *Annual Survey of Hours and Earnings*, provisional results for 2013 published December 2013.

[57] These figures are from HESA, *Destinations of Leavers from Higher Education Institutions 2012/13.*

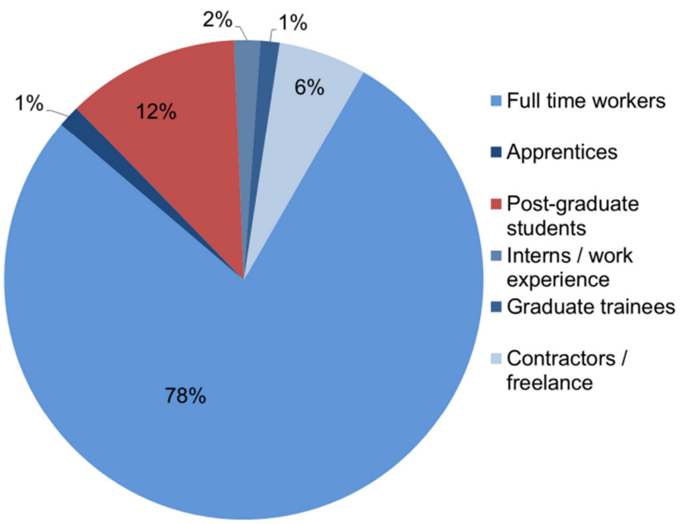
Employment of students in Higher Education

A significant 12% of IRT organisation employees are still on postgraduate courses according to the survey of AIRTO members (Chart 7.2). And while interns and others undertaking work experience are much less significant as a share of the total respondents' workforces, 73% of survey participants offer work experience opportunities of some kind (Chart 7.3), with 50% offering internships.

The benefits of this to these companies in future, and to other businesses and the wider economy, can be significant. For example, a recent BIS research paper[58] looking into the impact of work experience on higher education student outcomes concluded that:

"… respondents who had undertaken both work-based learning and paid work tended to have the most positive outcomes while those who had undertaken no work had the least positive outcomes. The magnitude of the effect of the different forms of work on the respondent's labour market outcomes can be judged to be relatively large, particularly for unemployment. The results of the study therefore provide some support for policies that aim to increase the number of students who participate in forms of work-based learning during their period of study."

Chart 7.2: Survey respondents' UK employment by type of employee



Source: Survey of AIRTO members 2014
(Survey sample size: 36)

The study found that experience of either paid work or learning-related work increased the probability of achieving a good degree, with that probability increasing by even more amongst those undertaking both. Those undertaking these forms of work (especially both) were also found to be more likely to be self-confident in comparison to those with no such experience, and to have a significantly lower chance of being unemployed – some 50% lower in the case of those undertaking both. The work experience groups were also found to have better odds of subsequently obtaining a graduate-level job, and to earn higher wages on average.

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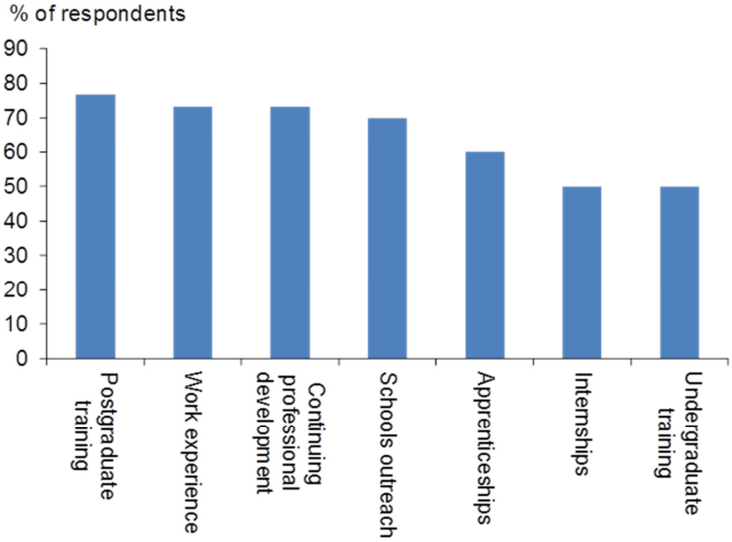
[58] BIS, *Learning from Futuretrack: the impact of work experiences on higher education student outcomes*, BIS research paper no. 143, 2013 (written by the Higher Education Careers Service Unit).

Chart 7.3: Survey respondents' training and work experience offering



Source : Survey of AIRTO members 2014

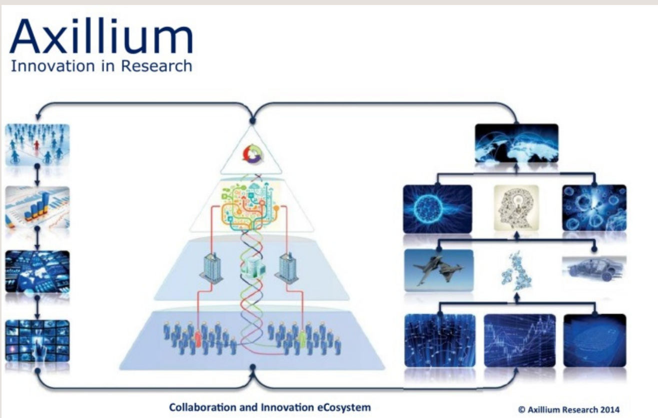
(Survey sample size: 30)

Engagement with schools

Although the research reported above related specifically to students in higher education, there is no reason to suspect that engagement by school-age individuals with the world of work could not have positive outcomes along equivalent lines. As Chart 7.3 also shows, 70% of respondents to the survey engage in schools outreach programmes. The involvement of Axillium Research with Daventry University Technology College (Box 7.7) provides a good real-life example of an IRT organisation's engagement with school-aged students, in terms of readying them for skilled engineering and similar work in due course.

Box 7.7: Case study on partnership with a University Technical College: Axillium Research

Axillium Research is a high-performing business, presently with nineteen staff, and recognised leaders in open innovation, collaboration management, and delivery of strategic technology programmes. Partnerships with universities and University Technical Colleges are central to the company's activities. Founder and Managing Director, Will Searle, is an industry governor of Daventry University Technical College (DUTC) and the college is partner in Axillium's Research & Development projects, offering insight and access to budding engineers and innovators as part of a training programme in advanced materials for automotive, aerospace and defence use.



Industrial training experience such as this forms a key part of DUTC's wider curriculum. Students aged 14-19 are offered an innovative mix of academic studies, technical learning, employer-led design projects and work placements based around specialisms in the fields of engineering, modern construction methods and environmental sustainability. The college first opened in September 2013 and in January 2014 students moved into a new, purpose-built building, fitted out with an array of specialist equipment.

Provision of apprenticeships and other training

Chart 7.3 above further shows how 60% of respondents to the survey offer apprenticeships, with 77% offering postgraduate training and 73% continuing professional development. AIRTO members offering apprenticeship schemes include AWE, which runs the well-established academy for staff embarking on their careers at the company (Box 7.8), and QinetiQ, which spearheaded 'The 5% Club' (Box 7.9).

Box 7.8: Case study on the provision of apprenticeships: AWE

AWE is contracted by the UK Government to manage and maintain the nation's nuclear defence capability, being responsible for providing innovative solutions to national nuclear security and for supporting the Continuous At Sea Deterrence programme.

The AWE Skills Academy supports the development of apprentices as they start their careers at the company. Since its inception 60 years ago, over 4,000 young men and women have successfully completed apprenticeships, and over 550 former apprentices are with AWE today – many in management and supervisory roles. The Academy has consistently created a strong pipeline of new specialists in engineering and technology, developing the capability needed to support successful delivery of AWE's work programme.

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AWE has been recognised in the Top 100 Apprenticeship Employers list, announced at the National Apprenticeship Awards at The Skills Show in Birmingham in November 2013. This list, compiled by the National Apprenticeship Service and City & Guilds, recognises excellence in businesses that employ apprentices. The Academy also won the BAE Systems Award for Large Apprenticeship Employer of the Year for the Thames Valley Region at the National Training Awards 2012. AWE apprentices recently recognised for their outstanding achievements include Louis McGee (Nuclear Apprentice of the Year for the South East) and John Webb (finalist in the UK Target Jobs Award – Advanced Apprentice of the Year).

Economic studies have found significant net benefits to apprenticeship schemes and other forms of vocational training, even after taking into account all costs, including the cost of output foregone as well as the learning provision itself. As a BIS research paper[59] highlights, these benefits include increased wages over the subsequent working lifetime of the learner and an increased probability of being employed. Spillover benefits are also possible including potential gains to future employers from increased productivity and gains to future employers, co-workers and others through knowledge transfer.

One paper[60] looking at wage returns from the government-backed Apprenticeship scheme (originally called Modern Apprenticeships) found the return to be 18% at Level 3[61] and 16% at Level 2. This research also suggested that the average return rose over the 1996-2005 period, that the return would vary significantly by sector and that returns on other vocational qualifications such as NVQs, BTECs and City and Guilds were lower (though still positive). Taking all costs into account, the net present value over the subsequent working lifetime of the average trainee was put at £105,000 at Level 3 and £73,000 at Level 2, even ignoring spillover benefits. The net benefits varied by sector but were found to be positive in all cases.

Quantifying the value of spillovers from training activities has proved more difficult but one paper[62] suggests that the increase in productivity from training is double the increase in wages.

Box 7.9: Case study on the provision of apprenticeships and graduate training: QinetiQ

The 5% Club – Investing in a Generation

Over 18% of 16-24 year olds – nearly 750,000 young people – are unemployed in the UK.[63] And yet, in many sectors – particularly areas like science, technology, engineering and mathematics – there are skills shortages.

Providing 'earn and learn' opportunities for the young people of the UK is both a business and a social imperative. Through education and training schemes, the Government has done a good job to provide the right "push" towards a solution. But it is those organisations that provide skilled jobs, the demand side "pull", that can ensure more young people enter into apprenticeships and graduate training schemes. Doing this can help transform work-place skills and abilities in the UK, and at the same time, improve the prospects of Britain's youth.

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[59] BIS, *Measuring the economic impact of further education*, BIS research paper no. 38, March 2011.

[60] Steven McIntosh, *A cost-benefit analysis of apprenticeships and other vocational qualifications*, University of Sheffield research report RR834, 2007.

[61] The return is calculated as the increase in wages over the previous Level.

[62] Lorraine Dearden et al, *The Impact of Training on Productivity and Wages: Evidence from British Panel Data*, CEP discussion paper no. 674, February 2005.

[63] UK House of Commons Library, (2014), 'Youth unemployment statistics', September.

The 5% Club was launched in October 2013. Spearheaded by QinetiQ and supported by five founding members, this industry-led campaign aims to transform the fortunes of young people in the UK. All members commit to trying to ensure that 5% of their workforce is either on apprenticeship or graduate programmes. Members also commit to declaring publicly via their annual report or on their websites, what their current levels are.

QinetiQ reported in their 2014 annual report, that they are currently at 4.78 and their target is to achieve 5% by March 2015.

The goal of **The 5% Club** is to inspire a generation and give young people fresh opportunities, challenge the status quo and drive innovation. To do that there must be investment, investment in the skills of young people to drive innovation, growth and prosperity.

"These employers are rising to the challenge and playing their part by increasing recruitment of young people, providing them with the training to build both a career and to Britain's long-term success in increasingly tough global markets."

Rt. Hon. Matt Hancock MP, Minister of State Department of Business, Innovation and Skills.

The 5% Club already has the support of 44 companies, large and small, from a range of sectors, including engineering, construction, defence, retail, law and IT. Members include QinetiQ, AWE, KPMG and Tessella and The Club is supported by CBI and professional bodies.

More information can be found on The 5% Club website at www.5percentclub.org.uk

7.3 Contributions to wellbeing in the UK

IRT organisations generate further benefits through contributions to the formulation and achievement of environmental, social and other public wellbeing goals both in the UK and globally[64]. For example, Box 7.10 shows how BRE has made a substantial contribution to the cause of improved building standards, generating considerable environmental, health, safety and social benefits.

Box 7.10: Case study on building standards: BREEAM, BRE Environmental Assessment Method

BRE was formerly the government-owned Building Research Establishment but is now a research charity to provide an independent and impartial research-based consultancy, as well

[64] In the case of R&D-related benefits, wider 'public good' impacts of this kind are not included in the standard estimation of spillover returns set out in section 6.2.

as testing and training. BRE offers expertise in every aspect of the built environment and associated industries. The profits from these activities fund a number of centres of excellence, which ensures that BRE helps governments, industry and business to meet the challenges of our built environment. BRE operates worldwide, as well as having offices in the UK. Much of the research that BRE undertakes supports its work on the widely-known environmental ratings scheme, the BRE Environmental Assessment Method (BREEAM). Launched in 1990, this was the first voluntary assessment mechanism for buildings in the world.

Since then a suite of products has been developed, for example BREEAM in Use for optimising buildings in use, BREEAM Communities for planning issues, and other sector-specific versions covering e.g. schools, healthcare buildings and offices. BRE continues to develop the BREEAM suite of standards, adding Infrastructure and refurbishment. Since 1990 over a million buildings have registered for assessment and today some 250,000 buildings have certified BREEAM assessment ratings.

The method assesses nine criteria: energy, transport, health and wellbeing, water, materials, waste, pollution, land use and ecology. It adopts a ‘balanced score card’ approach, where the overall performance level can be achieved in a range of different ways, allowing for flexibility and innovation by the developer, but with minimum requirements having to be met in key areas. By including voluntary standards, BREEAM provides a means of encouraging industry leaders and innovators to go further and faster than required by regulation, which provides a base standard that can be raised over time only at a pace that is realistic for the majority of the industry.

Examples of innovation being stimulated by BREEAM and subsequently being incorporated into minimum standards regulations include: low flush WCs; water butts; smoke alarms; cyclists’ facilities at offices; the use of sustainable timber; space for the storage of recyclable materials; low nitrogen oxide emitting boilers; life cycle analysis of building materials; and avoidance of ozone-depleting substances.

According to UKTI estimates, the UK’s low carbon environmental goods and services market is the sixth largest in the world, being worth some £112 billion annually in terms of turnover. Construction-related activities form a substantial part of that market, thanks to BREEAM’s long history of assessment, its push to go beyond minimum standards and its creation of standards inspiring the industry to create high-performing buildings with new innovations. The annual value of BREEAM-assessed projects in the UK runs to tens of billions of pounds and, in addition, the earnings of British companies overseas on projects involving BREEAM products are estimated to be more than £1 billion per annum.

Further examples of contributions to environmental and related public wellbeing goals include the work of the National Physical Laboratory's Centre for Carbon Management (Box 7.11) and the National Nuclear Laboratory's involvement in Japan's post-Fukushima clean-up (Box 7.12). NNL's activities in this case also provide a good example of IRT organisations' involvement in the export of UK expertise, demonstrating global recognition of the UK sector as a trusted partner in a complex field.

Box 7.11: Case study on slowing climate change: The National Physical Laboratory's Centre for Carbon Management

The National Physical Laboratory (NPL) is the UK's National Measurement Institute and a world-leading centre of excellence for the development and exploitation of measurement science, technology, related standards, and best practice across a range of technical areas. NPL aims to provide world-class science with social and economic benefits to the UK, with its capabilities underpinning the UK National Measurement System amongst other things.

The National Physical Laboratory's lighting laboratory

The Centre for Carbon Management, set up within NPL in 2012, aims to address the following three areas:

- Climate data – reducing uncertainties in climate data;
- Carbon markets and accounting – providing the robust measurement required to account for price and trade carbon emissions; and
- Low carbon technologies – helping to develop and accelerating the take-up of low carbon technologies.

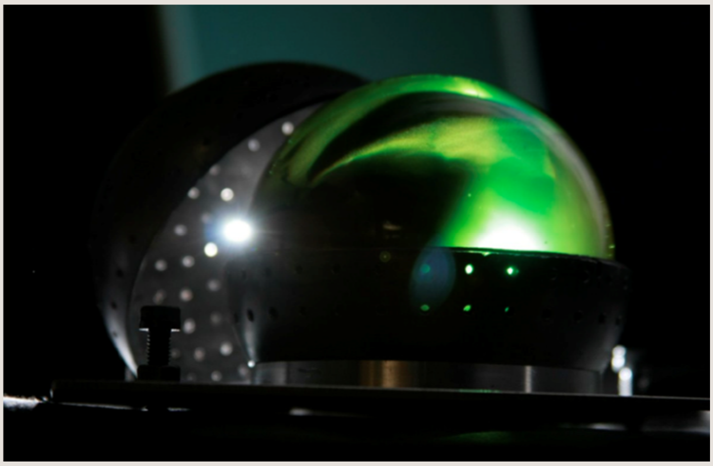
It does this by bringing measurement science to the challenging issue of climate change, and coordinating and collaborating with academic, business and government partners brought together in a strong stakeholder network. An independent report published in 2013 points to a **reduction of eight million tonnes of atmospheric emissions** as a result of the Centre's completed and ongoing project portfolio.

http://www.npl.co.uk/carbon-measurement/

Box 7.12: Case study on public safety and export of UK expertise: National Nuclear Laboratory

The National Nuclear Laboratory (NNL) plays a key role in the UK and global nuclear industry, with activities which include helping to reduce the cost of clean-up and decommissioning, maintaining critical skills and attracting talented new people to the industry. While these goals entail a strong domestic focus, the organisation also operates overseas, thus bringing in revenue from the export of UK expertise while helping to achieve globally-desirable policy outcomes.

An example of this is NNL's involvement in the Fukushima clean-up effort. The 2011 events in Japan left nuclear reactors there badly damaged and a substantial amount of radioactive material was dispersed within the reactor systems and beyond, creating a complex clean-up challenge. NNL immediately offered one of their experts with previous experience in Japan to take up a post as 'First Secretary, Nuclear' within the British Embassy in Tokyo, effectively acting as the link man between the needs of the Japanese and the wealth of nuclear clean-up expertise available within the UK. That person continues to be based in Japan, and has played a key role in the international clean-up effort.



The National Nuclear Laboratory's RadBall technology

NNL also came to an arrangement with Hitachi-GE Energy Ltd, in which the former's RadBall technology was evaluated for use in mapping the radiation levels in parts of the reactors, and for identifying the locations of the major contamination hot-spots. The technology is based on the use of a radiation-sensitive material to analyse the extent and location of radioactive contamination within confined spaces.

NNL continues to respond to competitive tenders for work as well as participating in UKTI-led events in Japan, where the company's experts contribute to round table discussions on the many challenges faced in the aftermath of Fukushima.

8 IRT organisations and public funding

Main points:

- In the latest financial year UK government funding (excluding competitively-tendered contracts) accounted for 31% of AIRTO member survey respondents' revenues in aggregate. But excluding public sector bodies and one other exceptional case, the share was 10% for commercial sector IRT organisations and 15% for not-for-profit organisations.
- On this basis UK government core funding and grants for the IRT Sector amounted to no more than 0.3% of total public expenditure. The funding was beneficial as it ensured that activities with the potential for significant spillover impacts went ahead when otherwise these developments may not have been viable on purely private funding, given the risks involved.
- Research suggests that every £1 spent by Innovate UK in recent years has generated, on average, £7 for the wider economy and that, more broadly, every £1 of public spending on R&D adds £4 to the value of market sector output.
- The survey found a positive relationship between IRT organisations' own investment and expected future activity levels, and identified a range of financial, policy-related and other barriers to that investment.
- Taking all of this into account, we would expect any future enhancement to the level of government funding in this area to boost sector activity and generate significant additional private and spillover returns for the wider UK economy.

In this Chapter we examine the existing public funding to IRT organisations, the importance of that funding and why it is necessary, and the potential net benefits to the economy and society of enhancing elements of that funding going forward.

8.1 The present level of public funding

A relatively modest public sector outlay...

Based on the survey results, UK government funding (excluding revenues from competitively-tendered contracts) is estimated to account for 31% of IRT organisations' revenues, with grants and funding from overseas governments and the EU accounting for a further 10% (Chart 8.1). On this basis we estimate that UK government core funding and grants to the IRT sector amounted to broadly £2.1 billion in the latest financial year, or just 0.3% of total UK government spending[65].

The 31% figure is pushed upwards by the impact of the universities and other public sector bodies in the sample, as well as one particularly large plc. For other private companies in the sample, core government funding and government grants amount to 10% of total revenues. For the not-for-profit AIRTO members, the figure is 15%.

Including revenue from competitively-tendered contracts (25% of all receipts), total UK government spending benefiting these organisations amounts to around £3.9 billion, or 0.5% of total public sector outlays.

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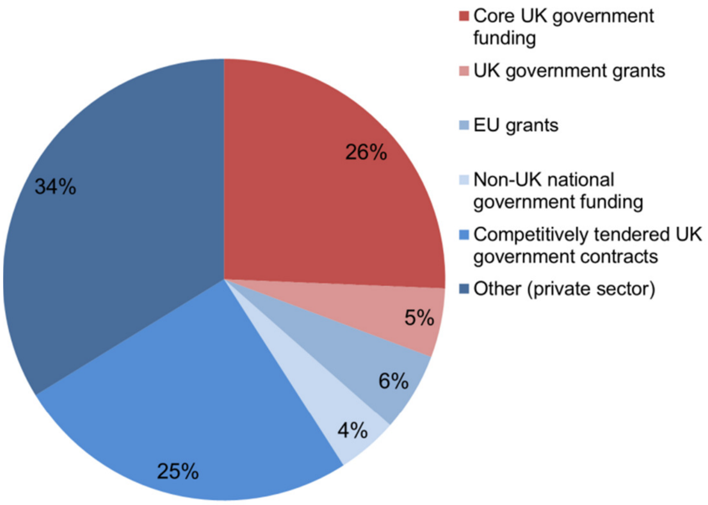
[65] Based on Total Managed Expenditure for 2013/14 of £715 billion, as reported in the March 2014 Budget.

Chart 8.1: Survey respondents' revenues by source



Source: Survey of AIRTO members 2014

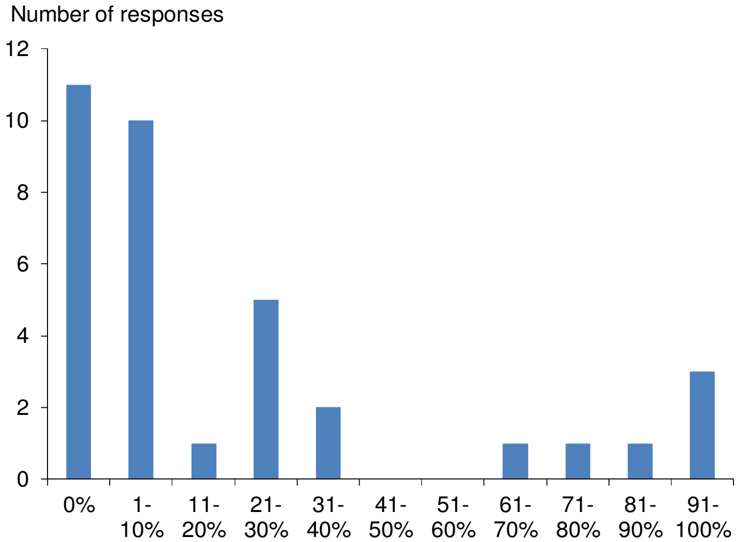
(Survey sample size: 35)

…which provides a firm foundation for the activities of many IRT organisations

Looking at the distribution of the impact of this public funding across the sector, Chart 8.2 shows that 21 AIRTO members believe that government funding provides critical support for up to 10% of their total revenue. Eight members feel this source of funding critically supports 11-40% of their total revenue. A further six members indicated that government funding critically supports 60-100% of their funding. Many in the latter category are Universities or publicly owned organisations.

Chart 8.2: The importance of UK government funding to AIRTO members

Survey respondents' view on the proportion of revenue that hinges critically on an element of government financing



Source : Survey of AIRTO members 2014
(Survey sample size: 35)

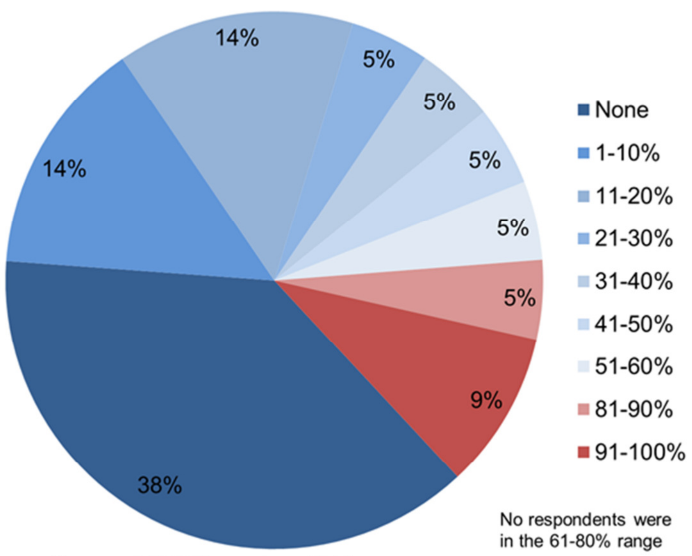
8.2 Benefits from this funding

This modest funding is necessary as the type of activity financed in this way – long-term investment in IRT organisations' infrastructure, expertise and skills development in the case of core funding, and projects of a more 'blue skies' or 'early stage' nature in the case of grants – might not be funded on a commercial basis even where the total eventual benefit to the economy as a whole was expected to outweigh the costs involved. That is because a great deal of the benefit takes the form of spillover benefits for third parties rather than private returns for the sector and its clients, as illustrated in Chapters 6 and 7.

This view, that recent public investment in science and innovation in the UK has resulted in net benefits to the wider economy, ties in with wider research-based evidence. For example, Innovate UK highlights how, in aggregate, every £1 that it has invested has returned £7 to the UK economy, with returns by area including at least £3 for feasibility studies, £9 for SMART awards and up to £35 in some areas of collaborative R&D[66]. A report for The Campaign for Science and Engineering[67] meanwhile suggests that more generally every £1 of public expenditure on R&D would add 20 pence to private sector activity for each year in perpetuity – so that a one-off additional spend of £450 million (some 5% of the total annual public sector R&D budget) would add £90 million per annum to market sector output. On the basis of reasonable assumptions, the report puts the net present value of that amount at £1.8 billion – implying a return of £4 for every £1 of public investment in this case.

Chart 8.3: The importance of government funding for capital investment

Survey respondents' view on the proportion of capital spending that is triggered by work critically dependent on an element of public funding



Source : Survey of AIRTO members 2014
(Survey sample size: 21)

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[66] Innovate UK, *Record £440million budget to support innovative companies*, press release of 14 May 2013, and *The facts – a pocket guide – third edition*, November 2013. For collaborative R&D projects, the average return is put at £6.71 for each £1 of TSB investment – see PACEC, *Evaluation of the collaborative research and development projects*, September 2011.

[67] Jonathan Haskel et al, *The economic significance of the UK science base*, March 2014.

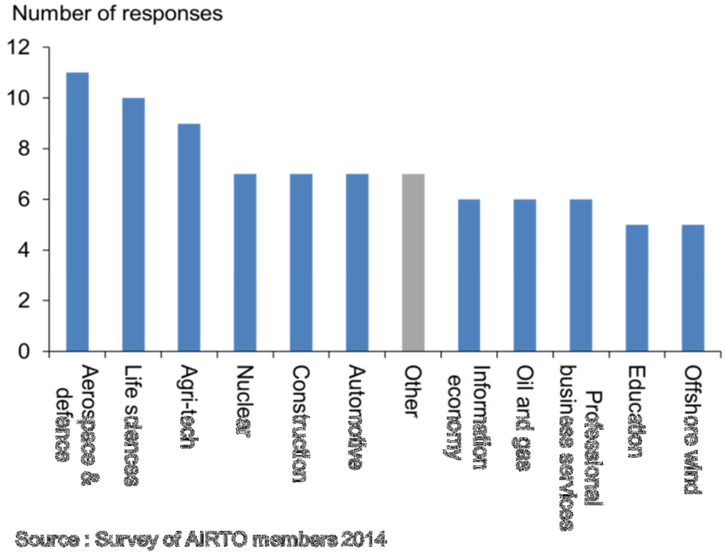
As part of this picture, where public funding of IRT projects elicits associated capital spending that would otherwise not take place, this will enhance the organisations' capacity to deliver not just on those projects but also on a wide range of further projects over many years. As Chart 8.3 shows, half of those responding said that 10% or less of their capital outlays was related to work dependent on public funding. One in seven respondents said that 80% or more of their capital expenditure was related to work dependent on government funding.

8.3 Potential benefits from future enhancements to this funding

Chart 8.4 shows how the work that hinges critically on an element of public funding is spread across a range of sectors. However, of the 25 organisations indicating that one or more types of activity fell into this category, only seven cited a non-BIS-priority (i.e. 'other') sector. Eleven pointed to aerospace and defence, ten to life sciences, nine to agri-tech, and seven each to nuclear, construction and automotive.

Chart 8.4: The role of government financing by field of activity

Survey respondents' view on areas of activity critically dependent on an element of government financing



Source : Survey of AIRTO members 2014
(Survey sample size: 25)

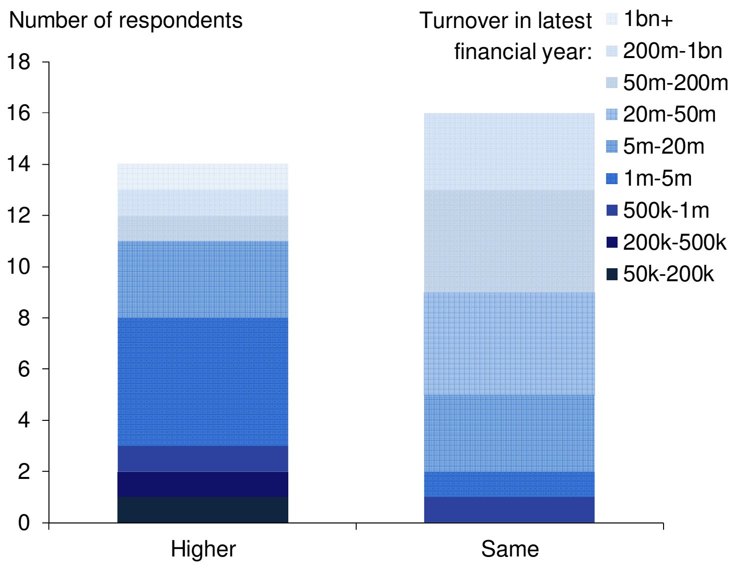
On its own, Chart 8.4 simply suggests that existing government funding of AIRTO members is 'working', in the sense that it is incentivising the organisations to undertake activity that they otherwise would not, in fields regarded as having the potential to contribute more significantly than the average to UK economic growth. However, together with indicators of the relationship between desired investment and revenue growth, existing barriers to such investment and growth, and survey respondents' views on public policy issues – all examined below – it is consistent with a view that additional core public investment in the sector would yield additional positive results.

Concerning the relationship between investment and growth, Chart 8.5 shows the results when participants were asked what band they expected their turnover to be in in five years' time, assuming (a) that they were unable to invest in new capacity felt to be desirable and (b) that this investment did go ahead. Sixteen out of 32 organisations answering both questions said that their turnover would be in the same band with the investment as without, while 14 survey participants believed that investment in desired capacity would lead to future revenues (and hence wider benefits to the economy) being higher than in the absence of the investment.

Nine out of these 14 organisations had a major focus on one or two specific activities (defined as contributing 40% or more of all receipts), with these activities including the BIS priority areas of construction, aerospace & defence, nuclear and automotive.

Chart 8.5: The importance of desired investment for growth in activity

Survey respondents' expectation for turnover in five years' time if desirable investment is undertaken, compared with expected turnover in the absence of that investment



Source : Survey of AIRTO members 2014
(Survey sample size: 32 AIRTO members)

Responding to an open question about the barriers that could prevent them achieving their goals for investment in new capacity, seven of the 36 survey participants cited finance-related constraints, including banks' reluctance to lend, inability to borrow, difficulty attracting equity investment, lack of profitability, pension fund deficits and resources consumed by taxation. In addition, eight cited lack of – or difficulty accessing – government financial support, with this embracing 'research funding', 'research and innovation infrastructure funds', 'support for technology development', 'funding for hi-tech scale-up capabilities', 'grant pre-financing for SMEs', 'funding for new nuclear energy R&D', 'uncertainty over the higher education funding regime' and 'lack of public investment combined with highly subsidised R&D competitors'.

Concerning actions that could be taken by the UK Government to drive growth in the sector, respondents set out a wide range of ideas, including actions to improve the availability of skills, a re-balancing of the use of existing public resources in this field and reductions in general business and employer taxes. However 19 members suggested measures likely to involve a net increase in public funding in the research and innovation field and/or tax reductions specifically focused on these activities.

9 Discussion and conclusions

Main points:

- The evidence set out in Chapters 6 and 7 shows how the sector generates value for the economy in ways far beyond the 'standard' direct, indirect and induced channels, which total £7.6 billion and support 140,100 jobs. The additional value generated includes significant gains for clients from the sector's R&D and non-R&D work, and spillover benefits for third parties from the R&D projects. The private and spillover benefits from the sector's R&D activity alone could be put at £9.8 billion on the basis of standard analysis, and are probably higher in practice due to the nature of the sectors of activity.
- In addition, we have shown with the help of case studies how the sector generates further value by enabling and enhancing gains from others' R&D, by helping to make the UK an attractive location for multinational investment, and by contributing to the development of the skills base. Taking into account environmental gains and other quality of life benefits as well, the magnitude of the sector's overall contribution to the UK economy is impressive.
- While very difficult to quantify in a robust manner, the relevant evidence that is available can be interpreted as consistent with the sector's overall contribution to the UK monetary GVA – including through all catalytic channels – being in the £32-£36 billion range. That is equivalent to 2.3%-2.6% of the national total, and could plausibly support some £13½ billion per annum in tax revenues. Important non-monetary contributions to society, such as to environmental and other policy goals, are on top of this.
- As these benefits include many captured by third parties rather than by the sector and its clients, they can only be achieved in full with the help of some justifiable public funding. But at 0.3% of total UK public expenditure, that funding is presently very modest.
- Taking all of this into account, as well as existing barriers to sector growth and further academic-type research, we are satisfied that modest amounts of additional public funding in relevant parts of the sector would yield significant additional gains for the economy.

An important element of this study has been to examine the extent to which six plausible hypotheses about the sector's economic role were supported by the evidence on the ground. The hypotheses were:

1. The sector's commercial connections, knowledge transfer role and other activities enhance the economic and social benefits of basic research.
2. The sector is a valuable part of the UK's innovation infrastructure and helps to make the UK an attractive place for investment by multi-nationals.
3. The sector provides a valuable training ground for developing essential skills and human capital.
4. The resulting contribution to the economy and society is significant.
5. These outcomes are achieved with modest, but nevertheless necessary, support from public funds.
6. There are areas where core investment in the IRT community would have a significantly beneficial effect on the UK economy.

9.1 How the sector generates 'catalytic' benefits for the economy

Hypotheses 1-3 are essentially concerned with some of the major 'in principle' channels through which the sector can deliver 'catalytic' benefits – that is, benefits over and above those measured by the standard 'direct, indirect and induced' metrics.

In relation to R&D-related benefits (hypothesis 1), sections 6.2, 6.3 and 7.1 explored how:

- The sector carries out a significant amount of R&D work itself on behalf of clients, with this activity expected on the basis of 'standard' analysis – grounded in academic research – to generate significant private benefits for those clients and potentially even greater benefits for the wider economy through spillover impacts.
- Given the fields of activity that IRT organisations are engaged in, other academic-type research suggests that these returns could be expected to be higher still in practice.
- IRT organisations facilitate R&D carried out by other entities, through activities ranging from joint project work with universities to the provision of appropriate state-of-the-art facilities for industrial businesses in innovative sectors.
- The organisations help to enhance the private and spillover returns potentially derived from others' R&D, through their own networking and collaboration and by providing facilities – such as at technology parks – for third party businesses to collaborate with each other.

Concerning the sector's role in making the UK an attractive place for business investment (hypothesis 2), section 6.4 set out how:

- Investment by multinational businesses makes an important contribution to the nation's productive capacity and is associated with jobs of a higher-productivity, higher-wage nature than would otherwise exist in the UK.
- Case studies show how, in practice, innovative project work by IRT organisations in collaboration with world-leading multinational manufacturers has boosted the productiveness and cost competitiveness of UK-based operations and ensured that new productive capacity and associated well-paid jobs are located in the UK – including in areas of above-average unemployment and below-average earnings.
- IRT organisations play an additional role in making the UK an attractive business location through their engagement in the public policy domain, including through involvement in Local Enterprise Partnerships in England which help to determine infrastructure and planning priorities.

With regard to the development of skills and human capital (hypothesis 3), section 7.2 explored how:

- IRT organisations employ a disproportionate number of highly-qualified staff, helping to ensure that the skills and knowledge acquired on academic courses are maintained and developed.
- They employ significant numbers of post-graduate students, and a majority offer internships and/or other work experience posts of various kinds.

- Academic research shows that students undertaking work experience (of the kind offered by the typical IRT organisation) are likely to attain better academic qualifications, higher competence levels and improved job and pay prospects compared with their peers.
- A majority of IRT organisations engage with school-age students through schools outreach and similar activities (e.g. partnerships with university technology colleges), thus equipping those students with vocational as well as academic skills.
- A majority also offer apprenticeships, with three quarters of IRT organisations additionally offering postgraduate training and/or continuing professional development to their employees.
- Academic research shows the net private returns to apprenticeships, other vocational education and other training (as offered by many IRT organisations) to be significantly positive, and suggests that there are likely to be significant spillover benefits in addition.

The evidence therefore supports the view that hypotheses 1-3 do apply to the IRT sector in practice.

9.2 The scale of the sector's economic and social contribution

Turning to hypothesis 4, concerned with the scale of the resulting economic and social benefit, the evidence presented in Chapters 6 and 7 showed how:

- The core economic contribution of the sector to the UK economy totalled £7.6 billion in 2012/13 – equivalent to over 0.5% of UK-wide GVA.
- This activity supported 140,100 UK-based jobs at that time (equivalent to over 0.4% of total workforce jobs) and was sufficient to generate in the region of £2.9 billion in tax revenues for the UK exchequer (just over 0.5% of all tax revenues).
- In addition to the core economic contributions, the private and spillover returns derived from the sector's own R&D activity would eventually settle at £9.8 billion per annum at today's prices if the recent volume of activity were maintained (based on a standard method of estimation). This value comprises £3.5 billion of private returns for clients and £6.3 billion of spillover returns for UK-based third parties.
- Real-life case studies show very substantial commercial benefits generated for clients as a result of IRT organisations' innovative project work. This appears consistent with the expectation that the returns on R&D will be even higher in practice than on the basis of the standard calculation, while also pointing to substantial client returns from IRT organisations' non-R&D services.
- Further substantial – though not easily quantifiable – private and spillover returns are generated by:
    - Activities facilitating R&D by other entities and enhancing the returns derived from others' R&D (through collaboration, networking and facilitating business 'clustering').

- Activities resulting in the location of globally-mobile high-value investment projects in the UK rather than overseas.
- Activities maintaining and enhancing the nation's skills and human capital base.

On top of all of this, the sector helps to improve national and global wellbeing through contributions to environmental issues, health, safety, and quality of life, as demonstrated by the real-life case studies in section 7.3.

On this basis, the total quantifiable contribution to the UK economy – direct, indirect, induced, clients' return on R&D and spillover return on R&D – is in the region of £17.4 billion per annum, equivalent to 1.3% of economy-wide GVA. But the sector's true overall contribution could easily be double that amount or more, taking into account the remaining catalytic channels.

Indeed, if every £1 of publicly-funded spending on work by the IRT sector yielded £5.50 in value for the wider UK economy – in line with the average of the ratios found by the reports for Innovate UK and Campaign for Science and Engineering (section 8.2) – then the sector's overall contribution to UK gross value added would be somewhat above £30 billion[68], though probably below £38 billion[69]. If the true figure fell into the £32-£36 billion range, it would be equivalent to 2.3%-2.6% of total UK gross value added (based on 2012-13 data). Non-monetary contributions to society, in the environmental and other public wellbeing areas, are also important and would be additional to these contributions to monetary GVA.

Table 9.1 summarises the results. The contribution of the 'other catalytic' channels is worked out as a residual between the estimated total and the robustly-quantified channels. These values – like the overall totals – should be regarded as tentative and indicative only.

The mid-point of this GVA range would be sufficient to generate total tax revenues of around £13½ billion, based on the economy wide tax-to-GVA ratio in 2012/13 – more than sufficient to cover the entire budget of either the Department for Transport or the Home Office[70]. However as most of the catalytic impacts act to boost productivity and pay rather than numbers employed[71], it is not clear that the overall number of jobs supported will be that much higher than the 140,100 provided through the direct, indirect and induced channels.

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[68] This potential minimum is calculated by applying the £5.50-to-£1 ratio to the 62% of sector turnover that is funded one way or another by the UK government or EU. To this we add a proportionate share (i.e. 38%) of the direct, indirect, induced, client R&D and spillover R&D impacts to capture the minimum benefit derived from other work. The overall return will be higher than this given further catalytic benefits from the other work (e.g. client returns from non-R&D activities and spillovers associated with skills development).

[69] Assuming that the rate of return estimates relied upon capture all of the catalytic channels, then the £38 billion figure would be reached only if the overall return on work for the private sector matched that for the public sector. That would be unlikely as spillover benefits accruing to third parties (rather than clients) will arise only as an accidental side-effect in the case of commercially-funded projects, rather than being an explicit objective as in the case of some publicly-funded work. (It would also require the benefits of work funded by foreign governments – some 4% of the total – to accrue mainly in the UK.) However it is possible that by relying on these two rate of return estimates, certain channels (notably those concerned with multinational investment projects and spillovers associated with skills development) are not fully captured, in which case it might just be possible for the 'true' overall value to be £38 billion or more.

[70] Put at £12.1 billion and £11.6 billion respectively for 2012/13, including all capital and current spending within Total Managed Expenditure. Source: HM Treasury, *Public expenditure and statistical analysis 2014*.

[71] Of these channels, only the encouragement of UK-based multinational investment is likely to impact on jobs in a significant way, and even then – as explained in section 6.4 – the final net impact on overall employment, as opposed to the impact on the number of 'well-paid' jobs, is likely to be limited.

Table 9.1: The overall contribution of the IRT sector to the UK economy

The overall contibution of the IRT sector to the UK economy			
	Gross value added, £ billion	Associated tax revenues, £ billion	Associated jobs supported
Direct, indirect and induced contributions	7.6	2.9	140,100
Client and spillover returns from own R&D projects ('standard' calculation)	9.8	3.9	n/a
Tentative estimate of other catalytic impacts[1,2]	14½-18½	6-7½	n/a
Total of all impacts[2]	**32-36**	**12¾-14¼**	**140,100**

[1] Additional returns on R&D project work due to the sectors of activity; returns for clients from non-R&D work; returns generated by enabling others to undertake R&D and by enhancing the returns to others' R&D; benefits associated with multinational investment projects; benefits from skills development.
[2] Including all contributions to monetary value added (in principle), but excluding non-monetary contributions to society in terms of helping to meet environmental and other public policy objectives.

9.3 The role of public funding

The above-mentioned £7 return for every £1 spent by Innovation UK is of course also relevant to hypothesis 5, namely that public funding of IRT organisations is modest but necessary. Other evidence supporting this view was also set out in Chapter 8, namely that:

- Based on the survey of AIRTO members, UK government core funding and grants paid to the sector amounted to little more than £2 billion in 2012/13, or just 0.3% of all public spending, even including exceptional cases and public sector bodies.
- Excluding those latter categories, this funding accounted for 10% of commercial IRT organisations' total income and 15% of not-for-profit IRT organisations' resources.
- For six of the 36 survey participants, more than 60% of their activity was critically dependent on an element of public funding.
- Most work deemed by AIRTO members to be critically dependent on an element of public spending takes place in BIS 'priority sectors'.
- For 14% of survey respondents, over 80% of capital expenditure is associated with work critically dependent on such funding.

Concerning the desirability of additional core funding – hypothesis 6 – while it need not follow automatically that extra public funding would yield the same net benefits as existing publicly-funded work, additional funding in this area does look to be desirable. As Chapter 8 highlighted:

- The survey results show a positive relationship between IRT organisations' desired capital expenditure and their ability to expand activities over a five-year horizon, with respondents identifying a range of financial and other barriers potentially preventing that desired capital spending from going ahead.

- Survey respondents suggested additional public funding, amongst other policy options, as a way of removing some of the perceived barriers to growth in activity.
- Academic-type work supports the view that additional public spending on science and innovation would yield significant additional benefits for the wider economy.

9.4 Conclusions

It can therefore be concluded that the innovation, research and technology sector makes a significant contribution to the UK economy. While the 'standard' measure of that contribution – through the direct, indirect and induced channels – is £7.6 billion, this value accounts for only a fraction of the total benefits generated by the sector. These include returns to clients and third parties associated with its R&D work, which can be put at £9.8 billion on the basis of 'standard' analysis but is probably even higher taking into account the fields of activity involved.

Further benefits include returns generated for clients by non-R&D work, and benefits for the wider economy from activities which:

- help others to undertake R&D and enhance the returns from others' R&D;
- help to make the UK a more attractive location for multinational investment;
- enhance the nation's skills base; and
- contribute to public wellbeing goals in areas such as the environment, health, safety and quality of life.

The potential scale of these benefits is illustrated by a range of case studies, although precise quantification is difficult. But taking into account findings that every £1 spent by Innovate UK yields a £7 return for the economy, and that every £1 of public spending on R&D yields a £4 return, we would put the sector's overall contribution to UK gross value added – including through all 'catalytic' channels – in the £32-36 billion range. That is equivalent to 2.3%-2.6% of national GVA and could be plausibly associated with the generation of £13½ billion of tax revenue annually. Some 140,100 jobs are supported through the direct, indirect and induced channels. Non-monetary contributions to public wellbeing goals are additional to these monetary benefits.

As these gains include a large amount of spillover benefits for third parties, they are only achieved in full with the help of justifiable public funding. However, at just 0.3% of all UK public expenditure, the value of government core funding and grants to the sector is presently very modest. Taking all of this into account, as well the existence of a range of barriers to investment and growth in the sector, there is clear potential for modest extra public funding in this area to yield significant additional returns to the UK economy.

10 Appendix

Table 10.1: Academic studies of the return to R&D

Academic studies of the return to research and development		
Author (year)	**Estimated private rate of return (%)**	**Estimated total rate of return (%)**
Terleckyj (1974)	29	48-78
Mansfield (1977)	25	56
Sveikauskas (1981)	10-25	50
Scherer (1984)	29-43	64-147
Berstein & Nadiri (1988)	9-27	10-160
Goto-Suzuki (1989)	26	80
Berstein & Nadiri (1991)	14-28	20-110
Nadiri (1993)	20-30	50
Average	**25**	**70**

Source: DTI Economics Paper 5: *DTI Strategy - The Analysis*, November 2003, page 17

Figure 10.1: Total returns to R&D by sector

Returns to R&D by sector of activity

Highest total return on R&D

Pharmaceuticals
Motor vehicles and parts
Aerospace
Electronics
Computers
Chemicals
Machinery and equipment
R&D services
Fuels
Utilities
Food, beverages and tobacco
Computer services
Precision instruments
Other transport equipment
Electrical machinery
Basic metals
Telecommunications services
Non-metallic minerals
Agriculture
Fabricated metal products

Lowest total return on R&D

Source: Oxford Economic Forecasting, *R&D Spillovers – Literature Review and Sector Ranking*, 2006.

Table 10.2: How AIRTO members were categorised for analysis within this report

AIRTO members' categories[1]			
	Private or public limited company	University or other public sector organisation	Company limited by guarantee or non-profit distributing
AFRC		x	
AHVLA		x	
AMRC with Boeing		x	
ARUP[2]	x		
AWE[2]	x		
Axillium Research	x		
BCIS			x
BHR Group	x		
BM TRADA			x
BMT Group Ltd			x
BRE Group			x
BSRIA Ltd			x
Campden BRI			x
CIRIA			x
City University London		x	
Connected Digital Economy Catapult			x
CPI			x
C-Tech Innovation	x		
Fera		x	
FIRA International Ltd			x
Fraunhofer UK Research Ltd			x
Fripp Design & Research Ltd	x		
Halcrow Group Ltd	x		
Health & Safety Laboratory		x	
High Value Manufacturing Catapult			x
HR Wallingford Group Ltd			x
Institute for Sustainability			x
ITRI Ltd			x
Leatherhead Food Research	x		
LGC	x		
Lucideon Limited			x
Medilink (Yorkshire & Humber) Ltd			x
MIRA Ltd			x
MTC			x
National Institute of Agricultural Botany			x
National Nuclear Laboratory	x		
National Physical Laboratory	x		
NCC			x
NNFCC			x
Nuclear AMRC		x	
PA Consulting Group	x		
Pera Technology	x		
QinetiQ	x		
Quotec Ltd	x		
Satellite Applications Catapult			x
SATRA Technology Centre			x
SCI			x
Smith Institute			x
Thames Innovation Centre			x
Thatcham			x
The Scotch Whisky Research Institute			x
Transport Systems Catapult			x
TWI Ltd			x
University of Greenwich		x	
University of Surrey		x	
WMG		x	

[1] AIRTO members as at June 2014 and therefore counted as such in the statistical analysis in this report. [2] ARUP and AWE are unique in their constitutional structures. They have been categorised for the purposes of this report as private companies, which is likely to be the most accurate single categorisation, but there are elements of other structures as well. For example, AWE sites and facilities are government owned while their management and day-to-day operations are private.

Table 10.3: Current AIRTO members (as at 1 November 2014)

AFRC Advanced Forming Research Centre, University of Strathclyde	The University Of Sheffield. Advanced Manufacturing Research Centre	Animal & Plant Health Agency	ARUP	Axillium Innovation in Research
BCIS Independent cost information for the built environment	BHR Group Experts in Fluid Engineering	BM TRADA	BMT Group	bre
BSRIA	Campden BRI food and drink innovation	ciria	City University London	Catapult Connected Digital Economy
cpi	C-Tech Innovation	emt east malling trust	fera	FIRA A BM TRADA Company
Fraunhofer UK	fripp design+research Solving problems through design	Health & Safety Laboratory	Catapult High Value Manufacturing	HR Wallingford Working with water
Institute for Sustainability	Leatherhead Food Research	LGC Setting standards in analytical science	LUCIDEON insight creating advantage	
Medilink	MIRA	mtc Manufacturing Technology Centre	NIAB	National Nuclear Laboratory
NPL National Physical Laboratory	National Composites Centre	NNFCC The Bioeconomy Consultants	Nuclear AMRC	Organic Research Centre Elm Farm
PA Consulting Technology Innovation	Pera Technology	QinetiQ	Catapult Satellite Applications	SATRA Technology
Science & Technology Facilities Council	Smith institute for industrial mathematics and system engineering	tic Thames Innovation Centre	Thatcham	The Scotch Whisky Research Institute
Catapult Transport Systems	TWI	University of Greenwich	University of Surrey	WMG Innovative Solutions

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