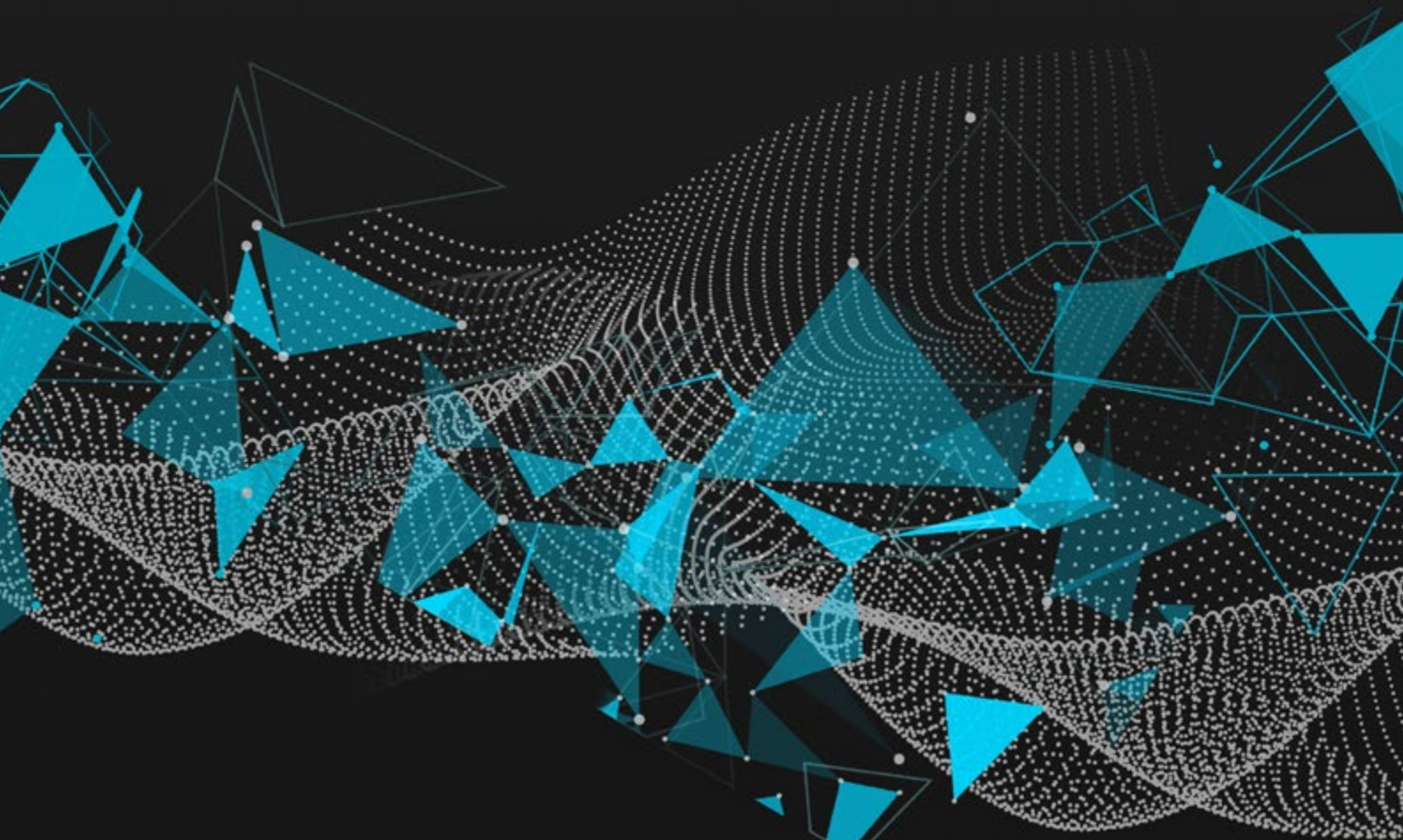




ARE  
**UNIVERSITY-INDUSTRY  
COLLABORATIONS**  
IN THE UK *REALLY*  
WORKING TO DELIVER  
**INNOVATION IMPACT?**



# DOES THE UK HAVE THE PULL-PUSH FORCE TO DRIVE INNOVATION?

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The Institute of Innovation and Knowledge Exchange (IKE) is the UK's professional body for innovators.  
It accredits and certifies innovation practices.  
The Institute's work is guided by the Innovation Council, which brings together over fifty senior  
business leaders representing different economic sectors.

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# INTRODUCTION

**T**his report seeks to use available data to explore the nature and recent dynamics of collaborative research by universities and industry. The focus of this collaborative research is predominately in the areas of Science, Technology, Engineering and Mathematics (STEM).



## The Triple Helix

The triple helix is a concept used to describe the interactions between universities, industry and governments that produce innovations and then increase productivity (Leydesdorff, 2000). An important linkage within the triple helix are collaborations between industry and universities (Leydesdorff and Zawdie, 2010). Therefore, this aspect of the triple helix is the focus of this report, reflecting the Governments ambition to increase productivity growth to levels seen previously.

## Period of Change

Stern Review (Stern, 2016) concluded that the Research Excellence Framework (REF) and the preceding Research Assessment Exercises had produced a high quality and exceptionally productive research base. Importantly, in terms of university and industry linkages the Stern Review recommended a “significant broadening and deepening of the notion of impact”. Additionally, the introduction of an Industrial Strategy (HM Government, 2017) has further identified four grand challenges which will influence future funding patterns. The challenges are: **AI & Data Economy**; **Clean Growth**; the **Future of Mobility**, and; the **Ageing Society**.

The Hauser Review (2014) identified the review of seven Catapults and nine key recommendations to ensure the development and continuation of the Catapult programme. Four years on from the Hauser Review, there are ten Catapults and seventeen Centres. The funding period for the Catapults was over a five-year period, with the first Catapult (High Value Manufacturing) having started in 2011, and thus the Department of Business, Energy and Industry Strategy (BEIS) commissioned Ernst and Young in 2017 to conduct a further Review of the Catapults which was published in November 2017.

The report found that approximately £1.25 billion had been received by the centres, of which about £745 million came from the public sector. Only the High Value Manufacturing Catapult had achieved its funding targets, with the others heavily reliant on public funding. The report criticised the strategies, governance and performance management of most of the centres, and made thirty-eight recommendations. Three centres – Digital, Future Cities and Transport Systems – were identified as in need of remedial plans, with the possibility of halting their further funding.



## New Institutions

Following the Nurse Review (2015) UK Research and Innovation (UKRI) has replaced Research Council UK (RCUK) as well as its constituent Research Councils as a single body. The UKRI is charged with driving forward innovation and the linkages between research and innovation as a strategic and interdisciplinary body.

Parallel with the formation of UKRI the Office for Students (OfS) replaced the Higher Education Funding Council for England (HEFCE). The OfS is responsible for regulating and funding the teaching aspects of Higher Education in England. Importantly, responsibility of the Quality Related research funding that used to be handled by HEFCE has been transferred to Research England part of UKRI.

These new institutions have had their missions changed from their predecessor bodies with a greater emphasis on **creating impact and innovation as well as greater employability for graduates**.

## New Emphasis on Impact

These changes have produced a new emphasis on “impact” by the universities and research funding bodies. Impact can either be because of influencing other academics or driven by economic and social imperatives. The following extract from the UKRI website provides a definition of impact from the funders point of view.



Impact is the demonstrable contribution that excellent research makes to society and the economy. This occurs in many ways – through creating and sharing new knowledge and innovation; inventing ground breaking new products, companies and jobs; developing new and improving existing public services and policy; enhancing quality of life and health; and many more”

UKRI website, 2018

Since generating impact through collaborative industrial partners is more likely to produce the level of desired outputs and outcomes within a short timeframe, the emphasis on impact has become a more prominent funding feature.

## Outline

This report starts by examining the evidence covering university and industry collaborative research. The next section provides data on the pattern of spinouts from universities. The third section explores the nature of Government incentives for collaborative research. The following section looks at the patterns of student flows into industry. It then examines the impact ratings from the 2014 Research Excellence Framework as a measure of university-industry collaboration. The final section examines international collaborations and has a summarising discussion and conclusions.



# UNIVERSITY INDUSTRY COLLABORATIVE RESEARCH

Despite the importance of higher education and industry linkages there is little consistent data covering this topic. There is some financial data which provides the first two figures. Figure 1 the University Income from Industry, is based on data collected by the OECD covering Research and Development (R&D) activities, in particular the proportion of higher education R&D that funded by industry. Then in Figure 2 the Proportion of Higher Education R&D Funded by Industry, there is a sample survey called the Innovation Survey which allows questions about the role of universities and partners and information sources to be analysed. The UK Innovation Survey is used to provide two tables

looking at differences by sector within the UK. The real value of the Innovation Survey is that it shares methods and questions used by the Eurostat's co-ordinated Community Innovation Survey. This allows the production of some international comparisons of the situation in the UK. Finally, Figure 3 in this section provides recent trends for outputs, including patents, from university industry collaborations.

However, it should be realised that none of these sources despite providing an overall UK and international view of university industry collaborations were primarily designed to analyse the topic. That means that each of the sources has limitations which are explored below.

## Value of University Industry Collaboration

Figure 1 shows that UK universities earned nearly £1.3 billion in 2016/17 as a result of collaborative research involving public funding. This is slightly less than the collaborative income in 2015/16 and a comparable figure to that earned from contract research. Contract research is usually externally funded research, including government funding. The expectation is that scientific understanding will be furthered, or that new conceptual ideas and inventions will be created. It is the intention that the results should always be published after minimal delays which may be necessary to protect arising IP.

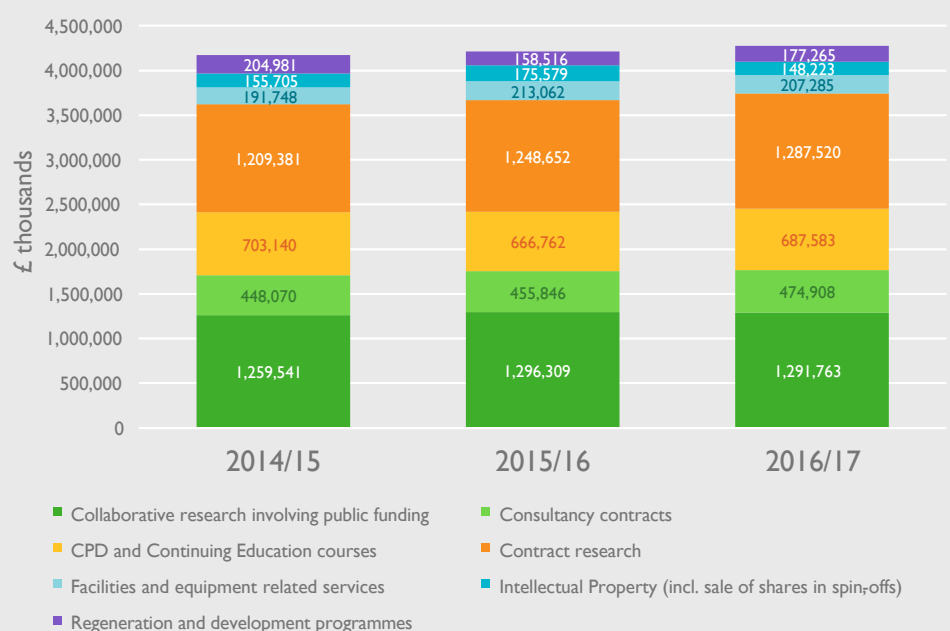
Other sources of income from industry include about £0.69

billion for Continuing Professional Development (CPD) and Continuing Education courses, and £0.47 billion for consultancy contracts. Consultancy contracts are usually funded by a business or organisation. The expectation is that the academic consultant will be able to apply their personal skill and experience to help a client business solve technical or other problems that are specific to the client organisation's business. Consultancy contracts carry fairly short timescales (a few weeks or months), and usually, this work has clear and well-defined deliverables. The client would normally expect to own the results of the work. Any publication arrangement is made by agreement with the client.

The expectation is that the academic consultant will be able to apply their personal skill and experience to help a client business solve technical or other problems that are specific to the client organisation's business



Figure 1  
**UK University Income from Industry, 2014/15 to 2016/17**



Source: HESA Higher Education - Business and Community Interaction survey

## Industry Funded University Research

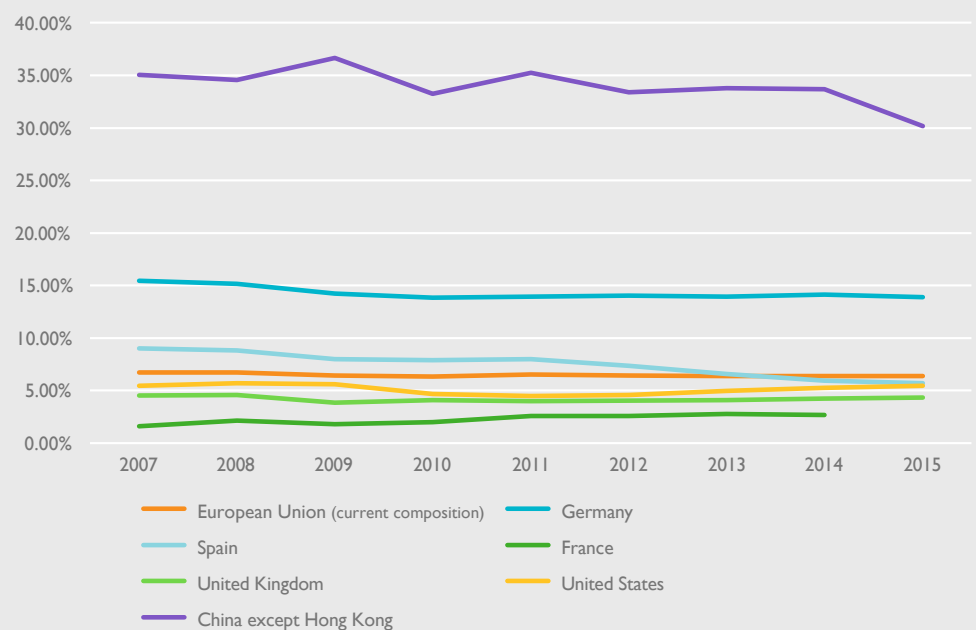
Another way of examining the extent of industry funded research is to examine survey returns from surveys of industrial R&D expenditures. Figure 2 uses OECD data showing the proportion of Higher Education R&D expenditure funded by industry for selected countries. This shows that in the UK just less than five per cent of universities R&D expenditure is funded by industry. The figure for the UK remains largely unchanged from 2007, apart from a slight dip in 2009 presumably as a result of the financial crash. The figures for Spain show a significant fall from

a high in 2007 of almost twice the proportion as the UK down to 5.7 per cent. Germany showed a slight decline from over three times the proportion of the UK to 13.9 per cent. Overall, despite these falls the proportion across the EU remained fairly constant. The striking feature of the data is in China where a significantly greater proportion of university R&D is funded by industry. Despite a consistent fall in the proportion from 35.0 per cent to 30.2 per cent of university R&D funding this still represents six times the proportion of funding in the UK.



The striking feature of the data is in China a significantly greater proportion of university R&D is funded by industry

**Figure 2**  
**Proportion of Higher Education R&D Expenditure funded by Industry**



Source: Eurostat R&D Expenditure Data



## UK Innovation Survey Results

The UK Innovation Survey asks a series of questions of a sample of innovative companies. Table 1 shows the results of asking the companies that engage in some form of innovation who they collaborate with, broken down by broad sectors. This shows that universities are generally a less likely collaboration partner than other businesses with their group, suppliers, customers or consultants and private R&D establishments. However, roughly a third of primary sector companies

(32 per cent) and engineering-based manufacturers (34.3 per cent) had collaborations with universities. In contrast, only 16.5 per cent of retail and distribution, and 16.4 per cent of non-knowledge-based services collaborate with universities. The concentration of focus across all sectors to look to others in their business group and suppliers shows there could be a lack of new thinking as industry is only talking to the same players, and thus creativity and possibilities for innovation are curtailed.

Roughly a third of primary sector companies (32 per cent) and engineering-based manufacturers (34.3 per cent) had collaborations with universities



Table 1

### UK Innovative companies collaborative partners, 2014

	Other businesses within enterprise group	Suppliers of equipment, materials, services or software	Clients or customers from the private sector	Clients or customers from the public sector	Consultants, commercial labs, or private R&D institutes	Universities or other higher education institutions	Government or public research institutes
Primary Sector	42.1%	69.3%	56.5%	34.9%	50.7%	32.0%	20.8%
Engineering-based manufacturing	48.0%	67.8%	70.1%	26.0%	31.9%	34.3%	21.3%
Other manufacturing	42.6%	62.5%	66.6%	26.3%	31.7%	23.2%	13.1%
Construction	48.7%	68.3%	68.4%	45.4%	29.5%	19.3%	14.1%
Retail & distribution	45.3%	69.7%	51.2%	29.0%	22.4%	16.5%	14.3%
Knowledge intensive services	49.4%	59.2%	63.5%	30.9%	28.3%	29.0%	14.4%
Other services	38.1%	72.3%	51.6%	31.6%	17.5%	16.4%	13.0%

Source: ONS UK Innovation Survey 2015

Table 2 shows the sources of information for innovation used by broad sectors of innovative UK companies from the UK Innovation Survey. This shows that generally universities are rated poorly in terms of sources of innovation information. It also shows that engineering-based manufacturers are much more likely than retail and distribution companies to source innovation information from universities. Six point three per cent of engineering-based manufacturers cited universities compared with only

one per cent of retail and distribution companies. The low percentage that universities have received as being sources of innovation information from industry suggests a lack of confidence in universities being places of innovation capability and expertise. Failing to address this perception will perpetuate a knowledge exchange of industry talking to the same people and getting the same level of innovation, and thus failing to achieve transformative or more leftfield innovation endeavours.

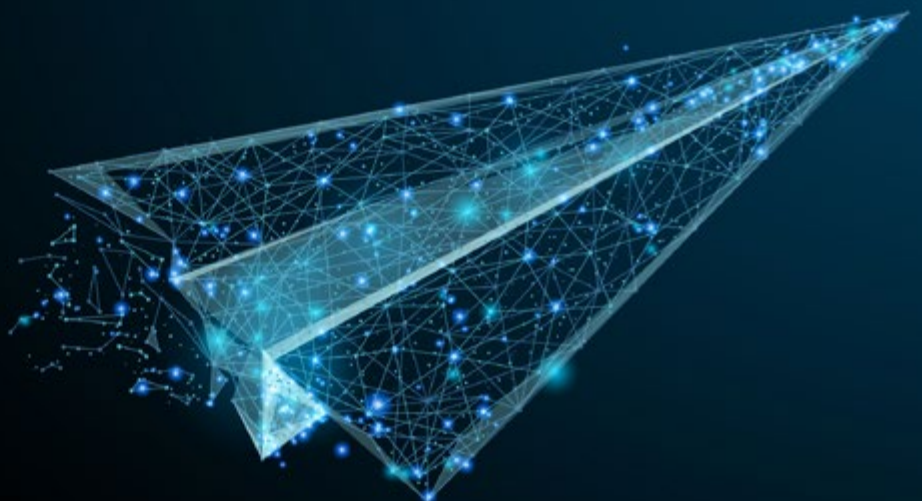
Table 2

### Sources of innovation information by broad sector, 2014

	Within your business or enterprise group	Suppliers of equipment, materials, services or software	Clients or customers from private sector	Competitors or other businesses in your industry	Consultants, commercial labs or private R&D institutes	Universities or other higher education institutes	Technical, industry or service standards
Primary Sector	67.0%	29.2%	9.9%	16.7%	6.6%	1.9%	9.0%
Engineering-based manufacturing	55.3%	22.8%	32.7%	16.8%	6.2%	6.3%	7.7%
Other manufacturing	52.5%	25.3%	22.2%	11.8%	4.8%	2.5%	6.4%
Construction	45.0%	22.2%	16.0%	6.9%	7.7%	1.5%	7.9%
Retail & distribution	47.0%	28.3%	17.5%	15.2%	3.6%	1.0%	3.2%
Knowledge intensive services	57.4%	17.5%	30.3%	18.5%	4.0%	3.0%	10.5%
Other services	39.7%	21.7%	16.6%	11.9%	3.9%	1.3%	4.7%

Source: ONS UK Innovation Survey 2015

The low percentage that universities have received as being sources of innovation information from industry suggests a lack of confidence in universities being places of innovation capability and expertise



## International Comparisons of Industry University Collaboration

Usefully, the UK innovation survey is part of an international exercise organised by the European Commission's statistical body Eurostat called the Community Innovation Survey or CIS. Table 3 provides comparable data from the 2014 Community Innovation Survey. This shows that the UK innovating companies are less likely than most EU countries to seek university collaborators. Notably, 64.6 per cent of German innovating companies collaborate with universities compared to only 30.9 per cent of UK innovating companies. Only Bulgaria, Estonia and Greece have lower proportions of their innovating companies collaborating with universities.

**64.6%** of German innovating  
companies collaborate  
with universities







The CIS data available from Eurostat includes information about the most valuable collaborators, including universities. Unfortunately, the UK data is not available for this question. It is again notable that for German innovative companies 25.2 per cent describe universities as their most valuable collaborator. In lieu of the UK data not available on who would be the UK's most valuable collaborator in innovation, it would perhaps be wise to suggest that a country that has only 18.8% of its enterprises co-operating with universities or other HEIs, but 96.6% of its enterprises co-

operating with clients or customers from the private sector; needs to re-examine the balance of where its research needs are being focused. Ensuring a strong innovation position internationally requires the UK to have a more balanced portfolio of innovation activities across all Technology Readiness Levels (TRLs) taking in the lower level TRLs that are typically more 'blue sky' but ultimately, could herald transformative breakthroughs all the way to higher level TRLs that are more applied or near-market research and development in their nature.

Table 3

### Type of collaborations as a percentage of all collaborators, 2014

	Enterprises co-operating with other enterprises within the enterprise group	Enterprises co-operating with clients or customers from the private sector	Enterprises co-operating with suppliers of equipment, materials, components or software	Enterprises co-operating with universities or other higher education institutions	Enterprises co-operating with Government, public or private research institutes	Enterprises co-operating with consultants or commercial labs
Bulgaria	27.4%	50.7%	63.6%	18.7%	8.3%	15.7%
Czech Republic	41.2%	44.8%	62.2%	37.1%	17.1%	25.8%
Denmark	45.5%	75.1%	71.5%	40.4%	17.7%	48.2%
Germany	30.8%	50.0%	35.5%	64.6%	45.7%	27.3%
Estonia	46.2%	67.5%	80.3%	25.5%	16.7%	35.5%
Greece	19.2%	82.4%	81.8%	24.8%	16.1%	53.8%
Spain	31.4%	53.1%	45.5%	33.9%	42.8%	25.0%
France	52.3%	49.6%	56.3%	34.1%	23.5%	35.1%
Italy	20.7%	46.1%	51.9%	35.9%	19.2%	46.2%
Netherlands	38.8%	76.4%	69.5%	37.6%	19.7%	27.2%
Austria	42.9%	65.6%	56.2%	44.8%	23.6%	35.3%
Poland	37.9%	45.5%	55.7%	37.5%	32.0%	24.9%
Sweden	58.6%	104.9%	77.0%	46.5%	:	51.9%
United Kingdom	48.5%	96.6%	65.3%	30.9%	18.8%	35.9%
Iceland	52.0%	64.2%	65.4%	31.3%	29.6%	40.2%
Norway	50.0%	76.9%	72.4%	33.3%	31.3%	55.9%
Turkey	80.2%	146.6%	86.9%	58.5%	53.8%	68.3%

Source: Eurostat Community Innovation Survey (CIS)



## Outcomes of UK University Industry Collaboration

Another measure of university industry collaborations is the production of patents and, in particular, patents filed by companies which list someone at a university as a co-inventor (Lechevalier et al. 2008). Figure 3, using data from HESA, shows that the number of patent applications has remained fairly constant rising from 2156 in 2014/15 to 2253 in 2016/17. However, there has been a significant rise in the number of patent applications filed by external parties who name higher education personnel (HEP) as a co-inventor from 1391 to 1858 patent applications. Overall, this has also led to a significant increase

in the number of patents granted to universities from 953 in 2014/15 to 1416 in 2016/17. Importantly, not every collaborative exercise leads to patents and some sectors such as information and communication technologies are less prone to patenting than others such as the pharmaceutical sector (D'Este and Patel, 2007).

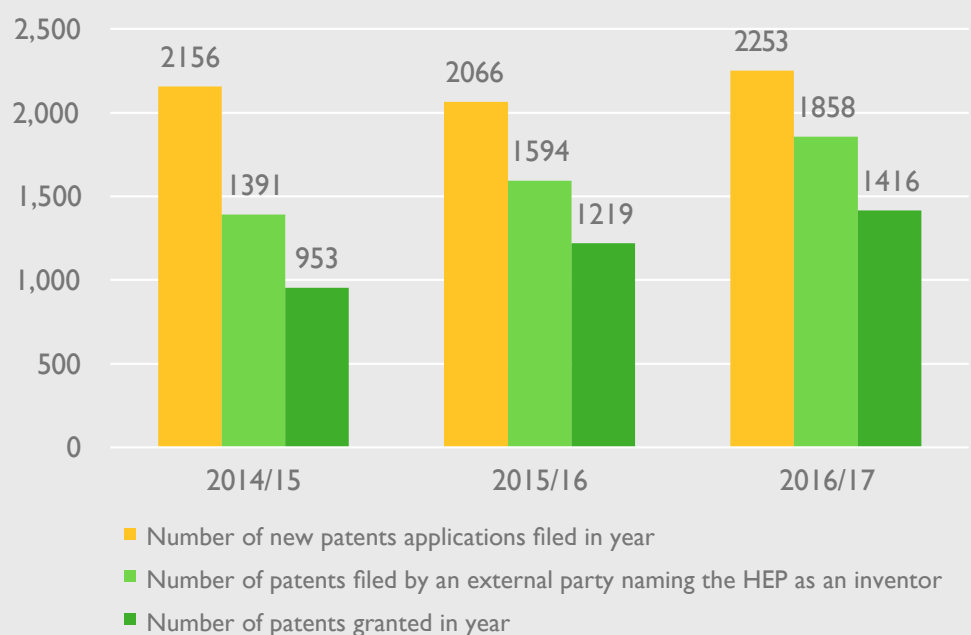
Co-publications involving people from universities and industry are a similar measure to patents of collaboration (Calvert and Patel, 2003). However, no recent UK analyses can be found.

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Figure 3  
**Recent Trends  
of Outputs**



Source: HESA Higher Education - Business and Community Interaction survey

## SPIN-OUTS FROM UNIVERSITIES

Spin-outs or spin-offs are companies founded by university staff to commercialise the outcomes of research (Wright and Fu, 2015). As such, spin-outs represent a form of collaboration between universities and industry. They also represent a critical aspect of universities support for entrepreneurship and local economic development (Guerrero et al., 2015).



### Nature And Number of Spin-outs from UK Universities

There have been a series of reviews of the nature of UK spin-outs (Wright and Fu, 2015, Hewitt-Dundas, 2015; Miranda et al., 2017). Figure 4 contains some data from HESA's Business and Community Interaction data collection covering the number of spin-outs from UK universities. The first thing that becomes immediately obvious is that the vast majority of recorded spin-outs are graduate start-ups.

What isn't immediately apparent is the degree of connectivity between possible research conducted by the graduate whilst in a university, and their subsequent decision to develop a new business venture. Is it that graduates are seeing the entrepreneurial life as one that is more rewarding than finding a job, or has there been a concerted effort on the part of the universities to drive this entrepreneurial spirit?

In the IKE Institute previous research paper 'Does Entrepreneurial Success Generate Economic Growth?' it was discovered that within a period of five years 90% of start-ups fail. The first two years of a start-up are the most crucial, with the report showing nearly 40% having failed by the end of year two. Given the high number of start-ups and evidence that this trend is growing, it would be prudent on the part of the government (BEIS particularly), to look to supporting, nurturing and growing this capability. In the past, such business support in the form of Business Links and other Local Enterprise support schemes have failed to deliver the requisite support to enable small businesses to flourish – the 90% of start-ups dying by the fifth year being evident of that. It is perhaps, now the moment - given the government's partiality for SMEs to take a greater role in the UK's business framework – for a different mechanism to be found to support these start-ups. As graduates are the creators of these start-ups, perhaps, a new business start-up support scheme over the first two years of a start-up's life (funded by government) could be developed and operated by Universities, aligned to their Alumni to ensure the start-ups survive

The question stands, however, are they increasing overall UK innovation capabilities in the right areas that are going to drive us as a nation forward?

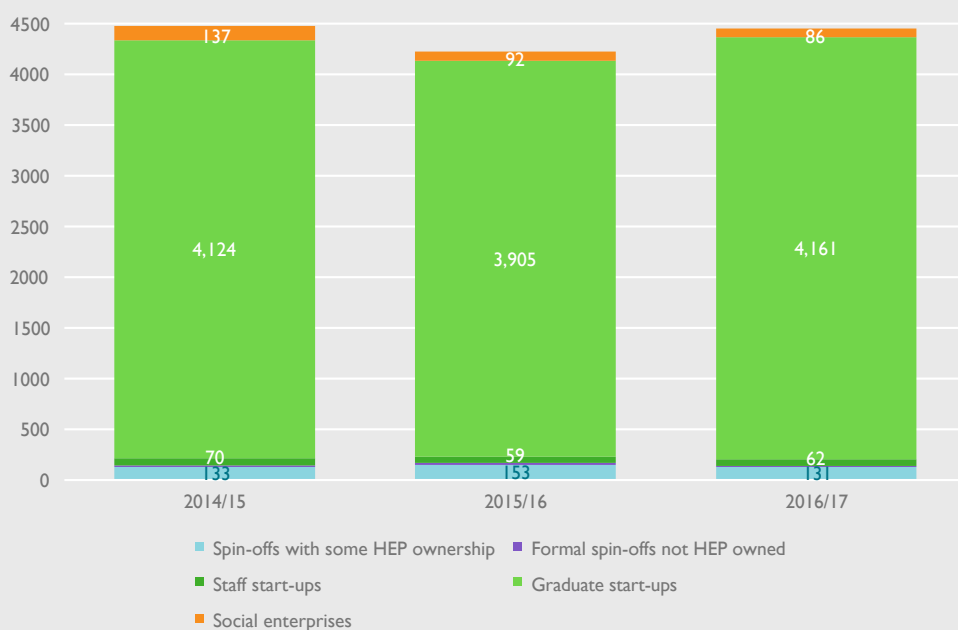
past the valley of death, and enter into an upward S curve.

Much has been written on Incubators and Accelerators, (including Pre-Accelerators, and Virtual Incubators and Accelerators), supporting their ability to enable start-ups to survive and grow. In BEIS April 2017 paper *Business Incubators and Accelerators – The National Picture*, the picture shows that both incubators and accelerators are on the increase. The question stands, however, are they increasing overall UK innovation capabilities in the right areas that are going to drive us as a nation forward? In the BEIS paper it highlighted 30% of Accelerators are non-sector focused and a further 23% are predominately IoT/Digital focused, and 45% of Incubators are non-

sector focused, with a further 29% that are focused on IoT/Digital. It is only the Life Sciences sector that have secured a 26% focus of all Incubators. It isn't known how many of the 4,161 graduate start-ups are aligned or linked to either an Accelerator or Incubator (physical or virtual), but one would hope that these graduate start-ups had been encouraged by the Universities to have some kind of relationship with one of the 205 Incubators and 163 Accelerators throughout the UK.

Apart from the graduate start-ups the next biggest category is spin-offs with some HEP ownership followed by social enterprise and then the smallest category staff start-ups.

Figure 4  
Number and Type of Spin-outs from UK Universities

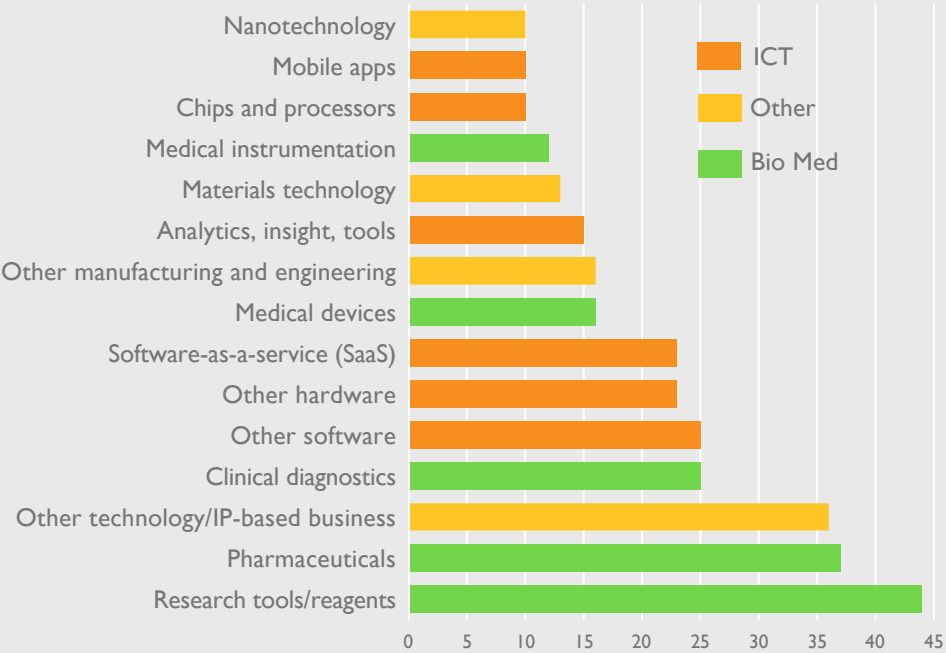


Source: HESA Higher Education - Business and Community Interaction survey

# Spin-out Sectors

There is relatively little information about the sectors in which university spin-outs operate or the main disciplines which produce spin-outs. Anecdotally, spin-outs are now the way in which bio-tech or genomic developments move to market and their subsequent takeover remain the way in which pharmaceutical companies obtain new products. Figure 5 provides some information from a broad sample of spin-outs about their area of operation. The sample comes from a database of fast growing companies receiving angel and venture capital funding maintained by Beauhurst. Beauhurst (2017) analysed their database to produce a report for Pennintons Manches. The figure confirms the anecdotal evidence as three of the four largest sectoral groups can be considered to be bio-medical.

Figure 5  
Number of 2016 Investments into Spin-outs by Company Sub-Sector



Source: Beauhurst (2017) Funding of UK Spinouts 2016-2017

The figure confirms the anecdotal evidence as three of the four largest sectoral groups can be considered to be bio-medical







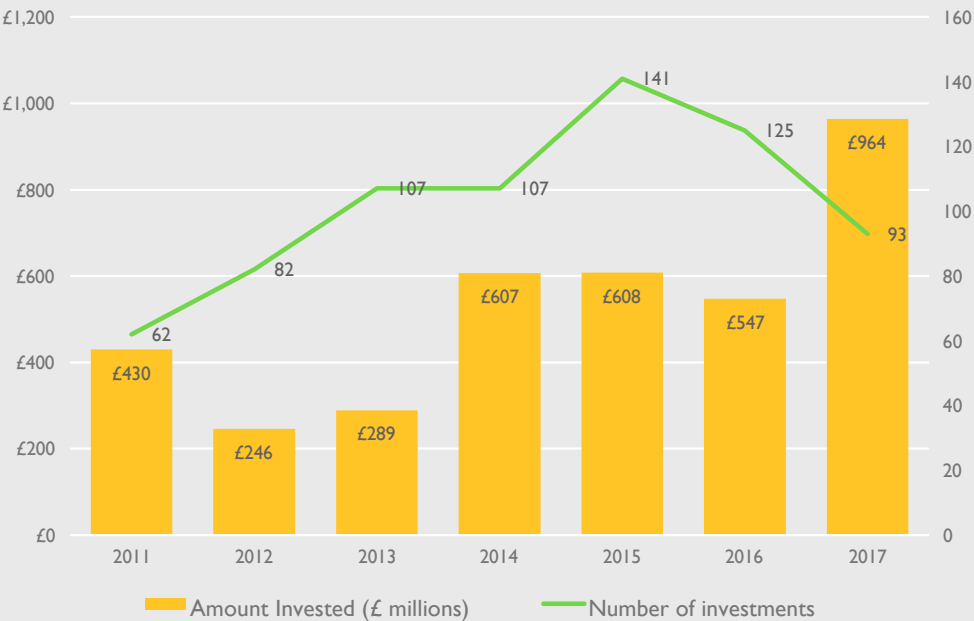
## Amount Invested in Spin-outs

Other available data on spin-outs from the Beauhurst authored report include details of the amount of money invested in university spin-outs. Figure 6 shows the amounts invested and the number of investment between 2011 and 2017. This shows that in 2017 nearly a billion pounds or £964 million was invested in university spin-outs in the UK. This investment came from 93 deals or on average £10.4 million each. The data also shows that the number of deals and the amounts invested have varied over time, but recently the average size of each deal appears to have increased. Does this increase in deal size mean

that there is a shorter supply of worthy spin-out opportunities – an indication of innovation capability decreasing – or is it that due to changing economics research engagements are naturally more expensive? Could it be that bigger investments pots are needed as spin-outs are being aligned or clustered around a smaller number of more important projects? Even so, a jump of 140% in deal size across a three-year period against a drop of project spin-out investment opportunities of 34% suggests something is happening in the UK innovation spin-out space and talent pool.

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Figure 6  
**Amount invested and number of investments, 2011 to 2017**



Source: Beauhurst (2017) Funding of UK Spinouts 2016-2017

# GOVERNMENT INCENTIVES AND FUNDING

Given the importance for the development of innovative products and services as well as the consequent productivity improvements the Government provides a range of incentives for university industry collaborative research. This section provides information about the main sources of funding available.



## Industry Strategy Challenge Fund

The Industrial Strategy Challenge Fund of over a billion announced in April 2017 is managed by UK Research and Innovation and as the name suggests aims to support the Government's Industrial Strategy. In particular, the fund supports the research base and innovative businesses in areas where:

- The UK already has world-leading research and businesses that are ready to innovate
- And, where the global market is large or fast-growing and sustainable



Currently the fund supports fifteen areas, as follows:

- Transforming construction – aims to transform construction to make buildings more affordable, efficient, safer and healthier
- National satellite test facility – aims to establish test facilities for space technologies
- Creative industry clusters – aims to help grow the creative economy
- Next generation services – aims to help the service industry take advantage of new technologies
- Manufacturing and future materials – aims to develop the next generation of affordable light-weight composite materials
- Driverless cars – aims to develop the AI and control systems that put the UK at the forefront of driverless cars
- Prospering from the energy revolution – aims to produce smart energy systems that link supply, storage and use of energy
- Faraday battery challenge – aims to produce high-performance batteries for electric vehicles and other applications
- Audience of the future – aims to create new and immersive experiences for people using virtual and mixed reality
- From data to early diagnosis and precision medicine – aims to produce new products and services using the health data available to the NHS
- Healthy aging – aims to help people stay active, productive and independent for longer
- Leading edge healthcare – aims to help individuals get the right drugs and treatments
- Quantum technologies – aims to take quantum effects out of the lab and into products
- Robots for a safer world – aims to develop AI and robots for extreme working environments
- Transforming food production – aims to develop more efficient sustainable food

One could argue that this list is far too diverse, and the funding requirements are dramatically different across this multi-sector list. Perhaps, it would be far better to concentrate the above list down in key economic STEM clusters, thus enabling a grouping by estimates of funding needed to be effective and proportionate to the anticipated resulting impact, rather than a scatter-gun approach with limited value criterion

## Global Challenges Research Fund



The Global Challenges Research Fund (GCRF) is a £1.5 billion fund announced in 2015 and uses Overseas Development Agency funds to support research collaborations that address the challenges faced by developing countries. These were managed by the individual research councils alongside a range of other bodies. However, with the advent of the UKRI these funds are being transferred to the central body.

## Impact Acceleration Accounts

The source of funding explicitly aimed at increasing the pace of impact are the Impact Acceleration Accounts introduced by many of the Research Councils. These funds are provided to those Research Organisations (RO) already in receipt of Research Council funding to increase the likelihood of commercialisation of the research and building Knowledge Exchange (KE) linkages with those outside academia who might benefit from the research. The key objectives of the funding include:

- To strengthen RO knowledge exchange through culture change, including through the development of skills for KE activity
- To strengthen RO and researcher user engagement
- To support knowledge exchange at early stages of progressing research outputs and outcomes to the point when they can be supported by other funding
- To support new, innovative and imaginative approaches to KE and impact, including processes that enable 'fast failure' and appropriate learning
- To support activities that enable impact to be achieved in an effective and timely manner, including secondments and people exchange.

These funds are operated by the:

- Engineering and Physical Sciences Research Council (EPSRC) – designed to strengthen links between academic researchers and partners beyond academia
- Economic and Social Research Council (ESRC) – designed to maximise the impact arising from ESRC grants
- Science and Technology Facilities Council (STFC) – designed to increase the training of academics in knowledge exchange and commercialisation as well as the commercialisation of and engagement with STFC funded research
- Biotechnology and Biological Sciences Research Council (BBSRC) – uses GCRF and ODS funding to promote economic development and welfare within low- and middle-income countries



## MRC Industry Collaboration Agreement



The MRC Industry Collaboration Agreement (MICA) encourages and supports collaborative projects between academic and industry researchers. MICA is flexible and can involve a range of industry contributions from cash and time to sharing compounds and staff.

## BBSRC Enterprise Fellowships

The Biotechnology and Biological Sciences Research Council (BBSRC) has Enterprise Fellowships that are designed to enable the recipient to concentrate on developing the commercial potential of their research, whilst also receiving formal training in relevant business skills.

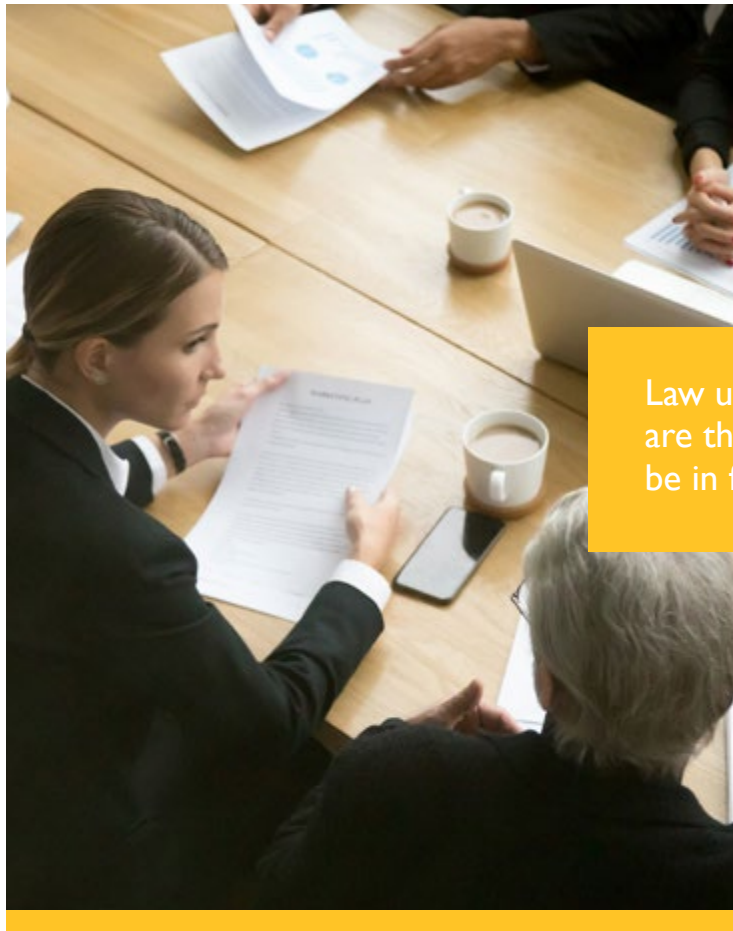
## BBSRC Industrial Partnership Awards

Industrial Partnership Awards (IPAs) encourage and support collaboration between academic research groups and industry. These are academic led projects requiring at least ten per cent match funding from industrial partners.

Given the changes occurring as a result of the formation of the UKRI many of the Research Council specific schemes may change soon and be replaced by more generic UKRI offerings and the UKRI may develop their own funding schemes to support impact. So, although these schemes and funding sources were current at the time of writing they may have been superseded. However, given the importance of collaborations and impact for the UKRI similar schemes will probably replace any removed.

# STUDENT FLOWS

An important component of university industry collaboration is the training of industrial recruits, especially those engaged in industrial research careers (Thune, 2010). This section uses headline data from the Higher Education Statistics Agency (HESA) to explore these issues.



## Undergraduates to Postgraduate Flows

It is difficult to get accurate measures of the numbers for undergraduates entering postgraduate research training, especially if periods of employment provide a gap between graduation and entering research training. In principle, a student's HESA unique student identifier follows them throughout their subsequent career; but this

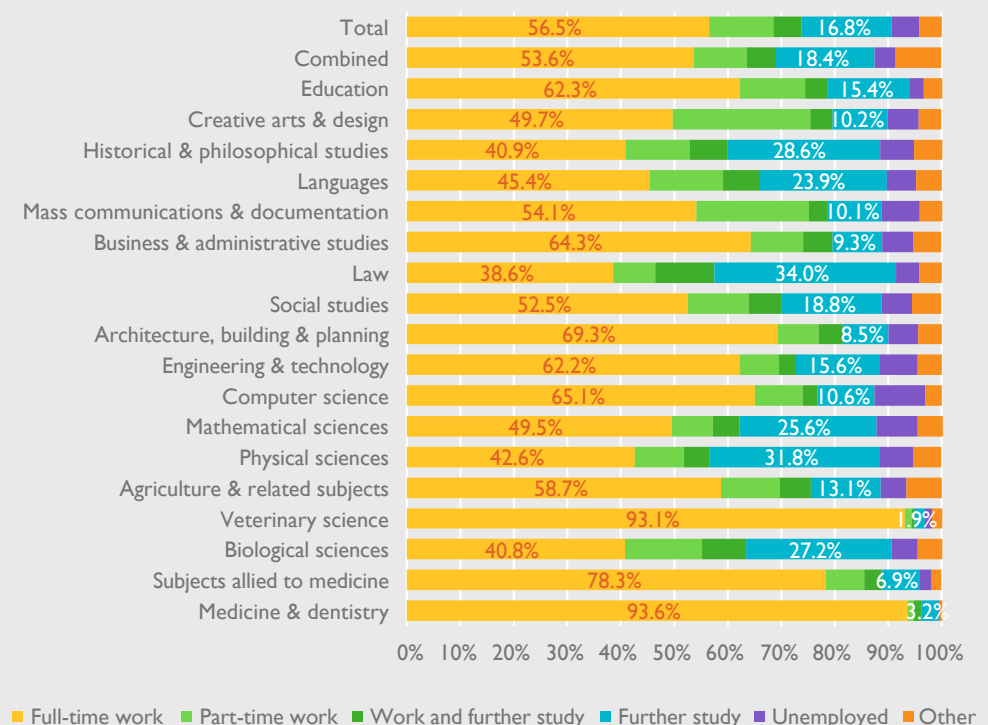
Law undergraduates are the most likely to be in further study -

# 34.0%

is not commonly used analytically. This means that from the standard analyses provided by HESA the best way of determining the proportion of undergraduates entering further research careers is shown in Figure 7. This shows the proportion of UK domiciled undergraduates by subject group who within one year of graduation enter various destinations including further research which includes Masters' as well as PhD's and other research-based qualifications. Law undergraduates are the most likely to be in further study (34.0 per cent) and veterinary science undergraduates the least likely at 1.9 per cent.

Figure 7

### UK Domiciled First Degree Graduate Destinations by Subject



Source: HESA First Destinations Statistics

## Doctoral Research Subjects

Figure 8 shows the gender breakdown of Doctoral degree starts in 2016/17 by subject. This shows that the largest subject group of doctoral students is biological sciences with the majority (60 per cent) female. The next two largest groups are dominated by males - engineering and technology (25 per cent female) and the physical sciences (37 per cent female). Other subjects such as social sciences are more evenly balanced by gender. While Education and languages are female dominated and computer sciences and mathematical sciences male dominated.

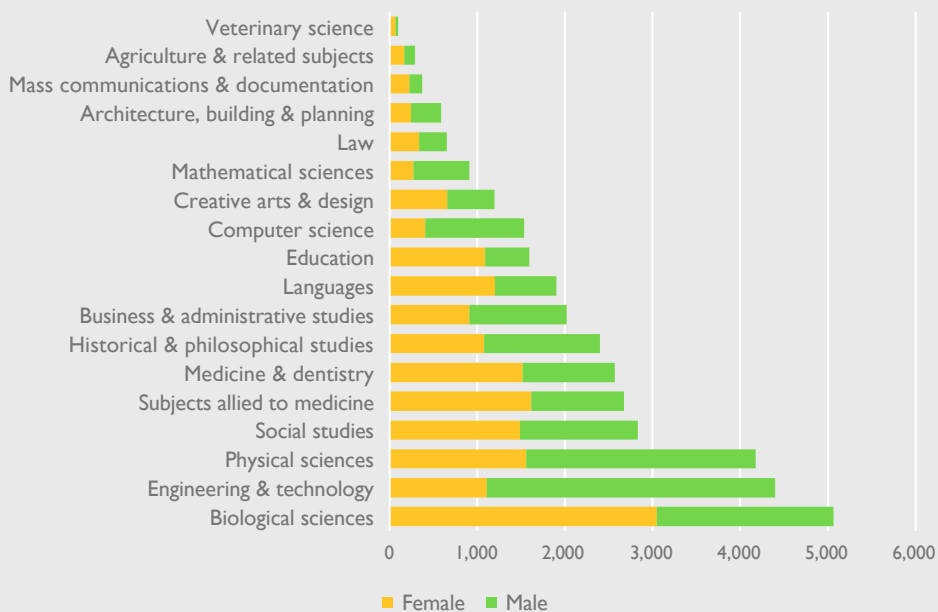
The largest subject group of doctoral students is biological sciences with the majority

**60%** female



Figure 8

### Doctoral degree starts by subject and gender, 2016/17



Source: HESA Student Numbers



The next two largest groups are dominated by males - engineering and technology (25% female) and the physical sciences (37% female)

## Doctoral Graduates Careers

Less than half (38 per cent) of doctoral graduates end up working in higher education. Table 4 provides a breakdown by subject grouping of the main destinations of doctoral graduates. This shows that overall 17 per cent enter higher education research and 21 per cent enter teaching within higher education and 12 per cent enter research occupations outside of higher education. In terms of subject groupings, 27 per cent of biological sciences doctorates enter higher education research, and, 44 per cent of social sciences doctorates enter higher education teaching. Biological science doctorates are also more likely to be engaged in research outside of higher education reflecting the importance of the pharmaceutical sector for UK industrial R&D.

Biological science doctorates are also more likely to be engaged in research outside of higher education reflecting the importance of the pharmaceutical sector for UK industrial R&D



Table 4

### Initial career paths of doctoral graduates by subject grouping, 2010

	Arts and humanities	Biological sciences	Biomedical sciences	Physical sci & Eng	Social sciences	Total
Higher education research	9%	27%	16%	19%	14%	17%
Teaching/lecturing in higher education	37%	13%	17%	10%	44%	21%
Research outside higher education	3%	21%	13%	16%	3%	12%
Other teaching occupations	14%	4%	3%	6%	8%	7%
Other common doctoral occupations	5%	19%	36%	30%	12%	23%
Other occupations	31%	17%	15%	19%	18%	19%

Source: Mellors-Bourne et al., (2013) *What do researchers do? Early career progression of doctoral graduates 2013*, Vitae





## IMPACT OF RESEARCH EXCELLENCE FRAMEWORKS AND IMPACT METRICS

The 2014 Research Excellence Framework not only examined the quality of outputs used by the earlier Research Assessment Exercises, but also examined the impact and the environment. Since the report is interested in impact, this allows the linkage of output excellence and the environment to impact to be examined.

### Output, Impact and Engagement Metrics

Table 5 provides the proportion of each unit of assessment obtaining the highest score of 4-star for their Outputs, Impact and Environment alongside the number of research active FTE staff submitted and the number of doctoral degrees awarded. Despite Clinical Medicine producing the highest (76.4 per cent) with 4-star impact being also the largest in terms of FTE staff and doctorates there is no clear pattern linking size and impact. Economic and Econometrics one of the smaller units of assessment has the second largest proportion with the highest level of impact. Similarly, there is no clear pattern linking, at the unit of assessment level outputs and impact or environment and impact.

In looking at Table 5, although Clinical Medicine has the highest proportion of 4-star Impact, the relative number of staff engaged in research resulting in PhDs is proportionately lower (47%) than Chemistry (85%) or Electrical and Electronic Engineering, Metallurgy and Materials with a higher percentage (73%) of the staff engaged in research resulting in PhDs. This perhaps indicates a higher level of efficient performance is being generated in Chemistry and Electrical and Electronic Engineering, Metallurgy and Materials Departments in Universities, to get more from less resources.

A higher level of efficient performance is being generated in Chemistry and Electrical and Electronic Engineering, Metallurgy and Materials Departments in Universities



Table 5  
REF 2014 Metrics by Unit of Assessment

	Category A FTE Staff submitted	Doctoral degrees awarded 2012-13	4* Outputs (%)	4* Impact	Social sciences
Clinical Medicine	3,571	1,699	23.1	76.4	59.4
Biological Sciences	2,373	1,355	29.3	47.8	57.9
Earth Systems and Environmental Sciences	1,380	607	18.2	36.2	31.2
Chemistry	1,229	1,047	22.1	39.6	38.0
Physics	1,704	779	21.3	37.0	44.0
Computer Science and Informatics	2,044	939	22.1	36.9	27.4
Aeronautical, Mechanical, Chemical and Manufacturing Engineering	1,152	719	18.0	38.4	36.8
Electrical and Electronic Engineering, Metallurgy and Materials	1,071	783	19.7	36.5	30.7
Civil and Construction Engineering	390	190	18.1	33.9	35.1
General Engineering	2,447	1,192	17.2	41.6	46.5
Architecture, Built Environment and Planning	1,025	323	22.7	38.4	43.2
Geography	1,686	532	22.1	34.3	40.9
Economics and Econometrics	756	225	27.7	36.3	33.4
Business and Management Studies	3,320	1,106	20.5	37.7	36.8

Source: REF 2014 Results

## Quality of Outputs and Impact

A smaller proportion of 4-star research is capable of delivering on both Output and Impact

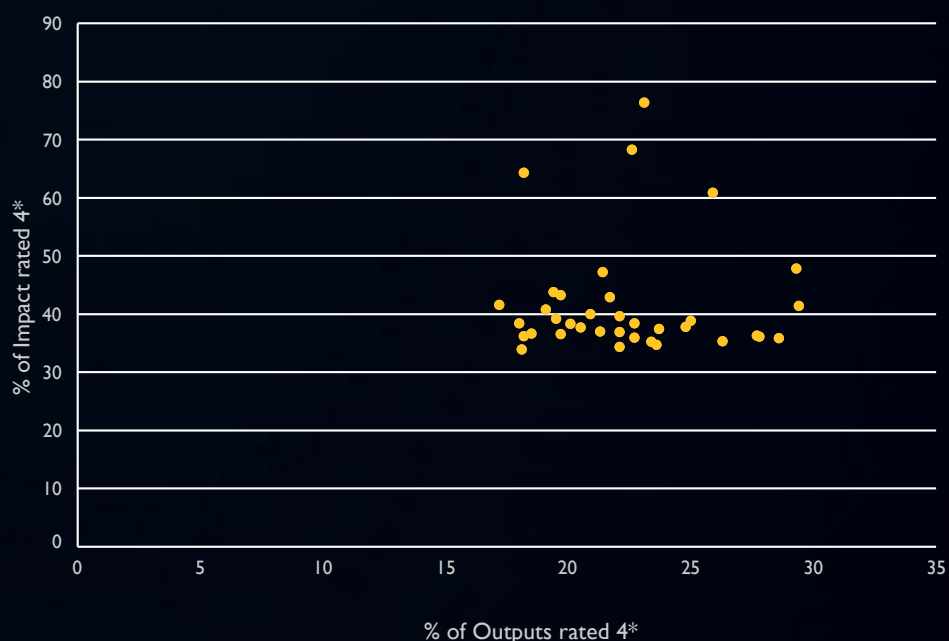
Figure 9 provides another way of examining the relationship, if any, between units of assessment producing quality Outputs and the quality of their Impact. The chart plots the percentage of output rated 4-star and the percentage of impact rated as 4-star. Overall, there is no clear pattern with no relationship between the two metrics. There appears to be

some clustering of the percentage with 4-star Impact ratings between 35 and 40 per cent, but this is across a range of 4-star Output percentages. The highest Impact percentages appear to be at the mid-point for the Output percentages. Later sections show that this lack of a clear relationship also applies at the institutional level and unit of assessment level within universities.

This disconnect between 4-Star Output Quality and 4-Star Quality of Impact identifies that a smaller proportion of 4-star research is capable of delivering on both Output and Impact. Could this be a contributing factor and perhaps, an underlying reason for higher investment deal sizes given to a smaller number of spin-out projects?

Figure 9

**Unit of Assessment per cent 4\* output and 4\* impact**



Source: Analysis of REF 2014 Results

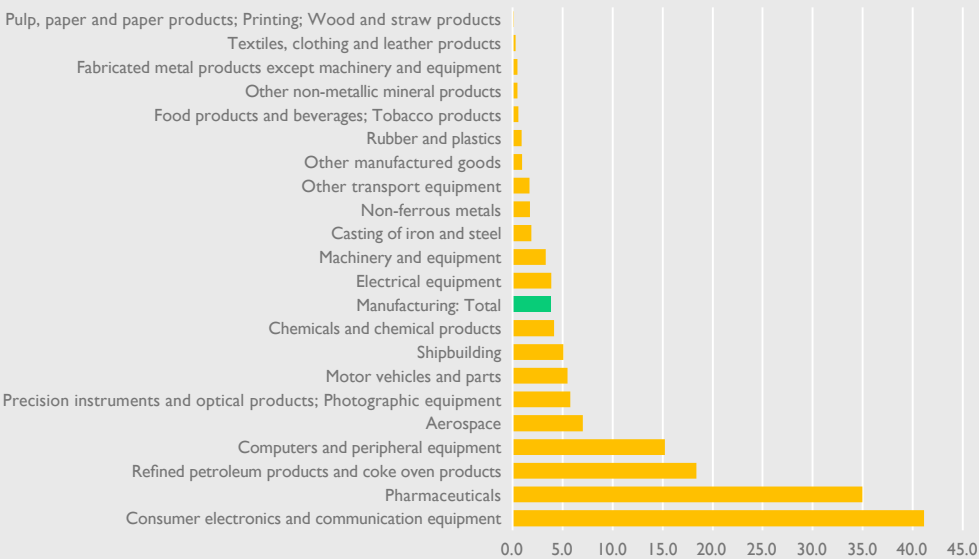


Those sectors that are more R&D oriented tend to generate much higher impact ratings in collaboration with their academic counterparts

## Impact and Sector R&D Intensity

There appears to be a clear linkage between academic disciplines and industrial sectors' R&D investment with respect to the intensity of impact. Figure 10: Manufacturing R&D average expenditure as a percentage of sales between 2013 and 2016, shows that those sectors that are more R&D oriented tend to generate much higher impact ratings in collaboration with their academic counterparts.

Figure 10  
**Manufacturing R&D expenditure as a percentage of sales (average 2013 to 2016)**



Source: Analysis of Research and Development in UK Businesses - 2016



# OPPORTUNITIES TO ACCELERATE INNOVATION THROUGH COLLABORATION

## International Collaborations

This section briefly examines the current extent of UK participation in EU funded collaborations.



Table 6 provides data from a BEIS analysis of European data on participation and budgets of the main EU science funding programme Horizon 2020. This shows that overall the UK has 13.8 per cent of participants and 15.7 per cent of the total budget. These figures need to be viewed in the context of an analysis of Higher Education Research and Development (HERD) expenditure across the EU and in the UK from Eurostat. This shows that the UK has 13.0 per cent of all EU HERD expenditure on a purchasing power parity basis between 2013 and 2016. This suggests that the UK is more successful than would be expected

in obtaining funding around pure science e.g. 'Excellent science' and equally successful around 'Cross theme science', 'Marie Skłodowska-Curie Actions' and 'European Research Council' funding. Overall, the UK gets more funding than would be expected on the basis of the extent of UK HERD funding. However, the areas of UK gain are in the purer sciences and not in the areas with greater industrial collaboration. Importantly, this significant source of funding for UK academic research is threatened by the possibility of a hard Brexit.

Table 6

### UK Participation in and funding from Horizon 2020 as of May 31<sup>st</sup>, 2018

	UK participations	UK share of total participations	EC funding to the UK	4* Impact
Excellent Science	4,337	18.9%	2,340	19.4%
Industrial Leadership	1,699	9.1%	663	10.0%
Societal Challenges	3,344	9.9%	1,519	12.3%
Spreading excellence and widening participation	51	7.7%	21	4.9%
Science with and for Society	82	8.2%	19	9.0%
Cross-theme science	87	18.2%	41	20.3%
Euratom	86	9.8%	46	7.1%
Total thematic pillars	9,686	12.4%	4,648	14.3%
European Research Council (ERC)	933	19.9%	1,280	19.9%
Future and Emerging Technologies (FET)	311	15.0%	174	15.9%
Marie-Sklodowska-Curie Actions	2,712	21.2%	694	20.6%
Research Infrastructures	381	11.2%	192	16.2%
Total Excellent Science	4,337	18.9%	2,340	19.4%
Total Horizon 2020	14,023	13.8%	6,988	15.7%

Source: BEIS (2018) UK Participation in Horizon 2020 (as of 31<sup>st</sup> May 2018)

## Discussion and Conclusions

There have been a series of academic reviews of university-industry collaboration (Perkmann et al., 2013; Banal-Estañol et al., 2015; Coletti and Landoni, 2017) including systematic reviews (Ankrah and Al-Tabbaa, 2015; Vick, 2017). Despite this effort there is little clear evidence of the drivers of university collaboration (Bruneel et al., 2010), the determinants of the success of any collaboration or the extent to which collaboration drives innovation. This is somewhat problematic, given the emphasis on 'Impact' in partly determining the level of university research funding. **The expansion of 'impact' is central to the current Government's strategy to drive up productivity through university led innovation.**

However, there is no evidence of any linkage between research quality at the unit of assessment (Chowdhury et al., 2016) or institutional level (Perkmann et al., 2011). This in turn suggests **simple linkage of Impact to funding will do nothing to improve the quality of research and it is unlikely to improve productivity.**

The higher impact ratings in subjects linked to industrial sectors with higher levels of R&D spending as a proportion of sales, such as pharmaceuticals suggests impact is more determined by the pull from industry as the push from

universities. As such, **it might be better to start with attempting to increase the demand for impact by industry** rather than pushing universities to engage in what could easily become inappropriate or ineffective impact efforts.

The linkages appear to be complex with proximity appearing to be important to success of university-industry collaboration (D'Este et al., 2013). Given the importance of personal links (Arundel and Geuna, 2004) and the

role of 'star' scientists (Schiffauerova and Beaudry, 2011), the importance of proximity would appear to make sense. **This concept of proximity also has conceptual linkages to the importance of regional links for innovation** (Caniëls et al., 2011; Laursen et al., 2011). This suggests a strategy at the regional or maybe Local Enterprise Partnership (LEP) or City Region level with local bodies that fosters local linkages should be further evaluated to assess the translational value of the impact on such ecosystems.



The expansion of 'impact' is central to the current Government's strategy to drive up productivity through university led innovation



For academic institutions to tackle the above questions a close collaboration underpinned by a commitment for cultural change on all sides is needed to improve the attitudinal barriers and accelerate the rate and quality of impact from university-industry research partnerships.

Should universities assess business impact of industrially-oriented research programme? Should they be responsible for distilling market, customer and competitive data alongside their technical research and feasibility studies?

For UK industry, the relationship between long-term academic investment verses a relatively low-value trade sale within shorter horizons will need to be re-evaluated. In shaping its direction of travel in a post Brexit era, the UK industry will need a fresh and intensified focus on its longer-term future capabilities, technologies and sovereign specialities. Thus, a commitment to developing high quality academic partnerships and encouraging academic institutions

to build their expertise over long periods should be one of the key planks future business strategies.

This is where Government funding and impact measurement instruments could play an important and stimulating role that encourages the formation of innovative university-industry collaborative models thereby, improving the quality, quantity and speed of generating sustained new earning power across the economy.

A different form of proximity also seems to be at work when there are collaborations involving multiple industrial partners from the same sector (Ponchek, 2016). **This suggests a strategy based around sectoral Catapults to develop the sector specific understanding of what is required for innovation.** However, it would be worth conducting a **comprehensive review of the effectiveness and relevance of research and innovation intermediaries** such as Catapults against sector-specific scorecards, recognising the pace of technological change in these sectors.

The spin-out data and the subject level information about impact suggest that collaborations are more plentiful and more successful with industrial sectors, which have a high commitment to R&D. This in turn suggests that **improving the pull from industry rather than the push from universities may increase the impact of university research.**

Improving the pull from industry rather than the push from universities may increase the impact of university research

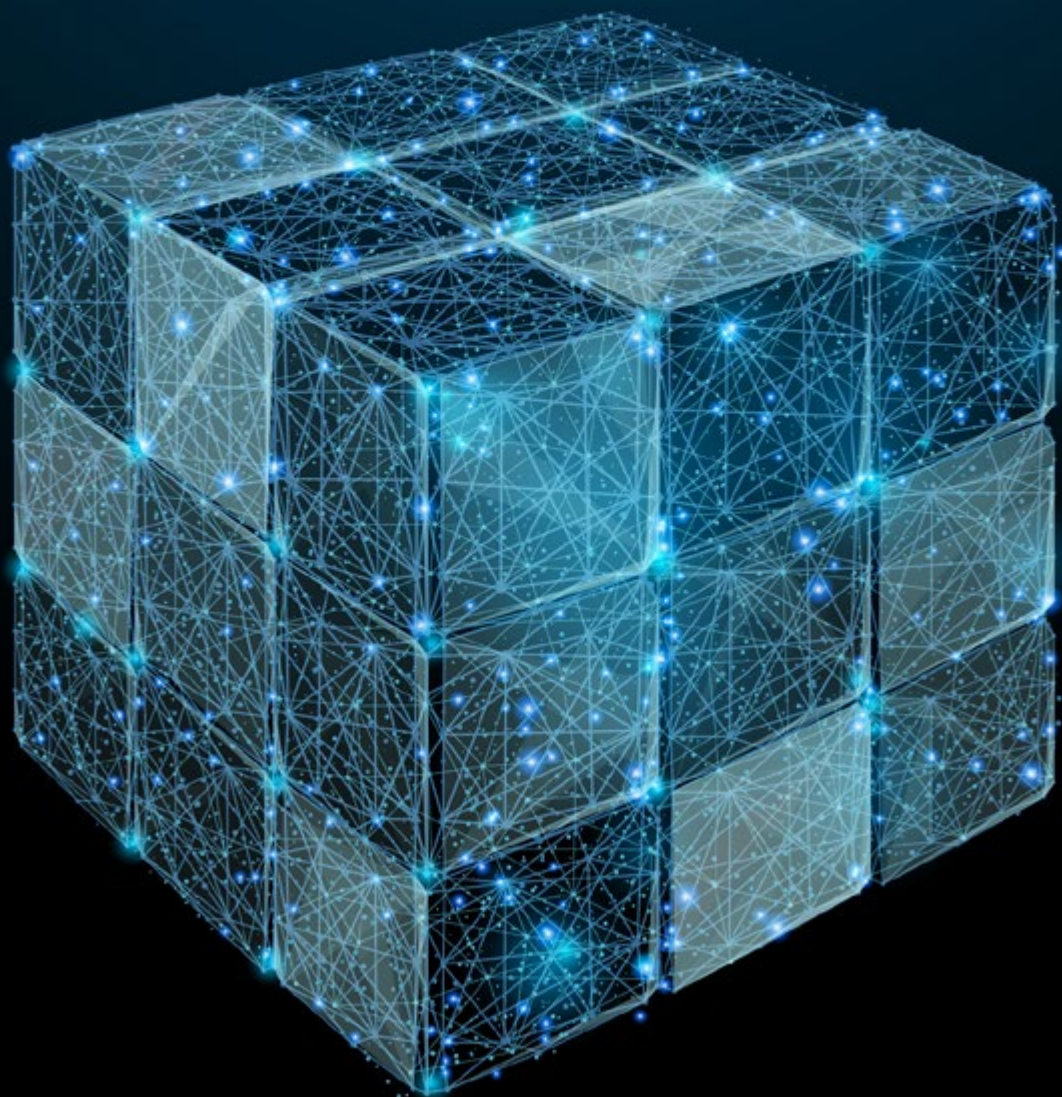




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